



Environnement
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**Program
Evaluation
Branch**

**Direction
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EVALUATION FRAMEWORK

**AIR QUALITY SERVICES
AND
ATMOSPHERIC RESEARCH**

September 1990

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DEFINITIONS

Basic Research: experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying phenomena and observable facts, without any particular application or use in view.

Mission-Oriented Research: research done with a clear purpose in mind usually involving applied research and experimental design activities.

Research and Development (R&D): creative work undertaken on a systematic basis to increase the stock of knowledge or to devise new applications.

Science and Technology (S&T): field of knowledge acquired by the systematic study, definition, and application of the laws governing natural and human phenomenon.

Related Science Activity (RSA): activities which complement and extend R&D by contributing to the generation, dissemination and application of knowledge.

Stratosphere: upper layer of atmosphere above 14 km.

Troposphere: lower layer of atmosphere, 14 km to ground level.

Cryosphere: earth's snow and ice masses.

ACRONYMS

AES	Atmospheric Environment Service
CCC	Canadian Climate Centre
CEPA	Canadian Environmental Protection Act
CAPMoN	Canadian Air and Precipitation Monitoring Network
EARP	Environmental Assessment Review Process
GCM	General Circulation Model
LRTAP	Long Range Transport of Air Pollutants
PERD	Panel on Energy Research and Development
SOE	State of the Environment Reporting
WMO	World Meteorological Organization
VOC	Volatile Organic Compounds

INTRODUCTION

1.0 INTRODUCTION

The purpose of this framework is to provide an agreed basis for the evaluation of the Air Quality Services and Atmospheric Research. Formulation of this framework consists of:

- component profile
- the identification of possible evaluation issues, performance indicators and potential data collection methodologies
- evaluation considerations.

Air Quality Services and Atmospheric Research is a sub-activity of the Atmospheric Environment Service (AES) activity. It provides a wide range of services from air quality monitoring to inter-environmental and meteorological research and development. The knowledge generated by the program provides the basis for timely and informed public policy decisions.

COMPONENT PROFILE

2.0 COMPONENT PROFILE

2.1 MANDATE

GOVERNMENT ORGANIZATION ACT (1979)

Air Quality Services and Atmospheric Research derives its mandate from the Government Organization Act (GOA) of 1979. The responsibilities outlined in the Act are to:

- (a) conduct research to advance the knowledge and understanding of the atmosphere including forecasting, climate change, atmospheric constituents, the impact of man's activities on the atmosphere, interface relationships between the atmosphere and land, water and the cryosphere, weather modification, and instrumentation related to the above;
- (b) promote the application and development of atmospheric science in Canada; and
- (c) participate in the planning and implementation of international scientific research and operational programs sponsored by international organizations and agencies.

2.2 OTHER ACTS AFFECTING AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH

CANADIAN ENVIRONMENTAL PROTECTION ACT (1988)

In addition, the Canadian Environmental Protection Act (1988) [which replaced the Clean Air Act (1971) and the Environmental Contaminants Act (1975)] provides the Environment Minister with a framework for protection against threats from toxic substances. This mandate includes actions to:

- ° formulate environmental quality objectives, guidelines, and codes of practice;
- ° establish and operate environmental quality monitoring and codes of practice;
- ° conduct research relating to the nature, transportation, dispersion and effects of environmental pollution, as well as provide related advisory and technical services;
- ° publish or distribute pertinent information to inform the public on all aspects of the environment.

2.3 SIGNIFICANT CABINET DECISIONS

Monitoring of the Protective Ozone Layer of the Stratosphere (MOPOL) (1981)

- ° authorizes DOE/AES to participate in research and monitoring of the stratosphere ozone layer in response to its depletion.

The Canadian Space Program (1981)

- ° authorizes Environment Canada to undertake a meteorological satellite R&D program in the interest of improved weather forecasting.

The Canadian Climate Program (1983)

- ° approves a research and monitoring program to determine the effects of the atmospheric "greenhouse" effect on climate.

Numerical Computation Facility for AES (1981)

- ° confirms continued program approval for a Canadian numerical weather prediction system and associated research.

Space Plan of the Interdepartmental Committee on Space (1984)

- ° authorizes DOE/AES to augment its ability to monitor atmospheric contaminants by remote sensing from space platforms.

Long-Range Transport of Air Pollutants (1984, 1985)

- ° approves a scientific and monitoring program on the acid rain problem in support of policy and abatement decisions.

Management of Toxic Chemicals (1981, 1984)

- ° supports a DOE program to address the sources, pathways, and effects of toxic chemicals in the environment.

2.4 INTERNATIONAL CONVENTIONS AND AGREEMENTS

WORLD METEOROLOGICAL ORGANIZATION (WMO)

- ° Under an agreement with the World Meteorological Organization, Canada agreed to archive and publish world ozone data. In addition, AES has agreed to operate a Canadian component of the WMO Background Air Pollution Monitoring Network.

VIENNA CONVENTION (1985) AND THE MONTREAL PROTOCOL (1987)

- ° Under the auspices of the Vienna Convention for the Protection of the Ozone Layer (1985) and the Montreal Protocol on Substances that Deplete the Ozone Layer (1987), Canada agreed to undertake, as appropriate, initiate and cooperate in research and systematic observations on the physics and chemistry of the ozone layer and its changes, as well as on the resulting effects on climate and UV-B radiation.

ECE CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION, (LRTAP, 1979) AND THE HELSINKI (1985) AND SOPHIA (1988) PROTOCOLS

- ° Canada agreed, as appropriate to their needs, to initiate and cooperate in research on methods of air pollutants involved in LRTAP.

GREAT LAKES WATER QUALITY AGREEMENT (1978, AMENDED 1987)

- ° Canada agreed to conduct research, surveillance and monitoring for the purpose of reducing atmospheric deposition of toxic substances to the Great Lakes Basin (Annex 15 of the Agreement).

U.N. RESOLUTION L.17/REV.1 (MALTESE RESOLUTION)

- ° This resolution dealt with the conservation of the climate as part of the common heritage of mankind. It urges governments to undertake and promote research in order to increase understanding on all sources and causes of climate change, including its regional aspects and specific time frames as well as the cause and effect relationship of human activities and climate.

2.5 RATIONALE

The rationale of Air Quality Services and Atmospheric Research is to provide leadership and a scientific knowledge base for informed decision-making in connection with the protection of health and safety of Canadians, and for the protection of environmental quality.

The program responds to a wide-range of environmental public policy issues such as acid rain and stratospheric ozone layer depletion that are currently rated high on the public agenda. The information base is essential for both dissemination of public information, and for assisting in determining the most appropriate use of policy programming instruments by the Government.

In addition, Air Quality Services and Atmospheric Research aims to develop and maintain, in Canada, an overall level of scientific and technological expertise in atmospheric science in order to contribute to and take advantage of worldwide scientific advances. This allows for responsiveness to environmental issues as they emerge as government priorities.

The rationale of Air Quality Services and Atmospheric Research reflects the evolving rationale of Environment Canada to anticipate and prevent environmental degradation.

2.6 OBJECTIVES

As outlined in Part III of the Estimates, the objectives of Air Quality Services and Atmospheric Research are:

- ° to provide scientific advice on regional and national air quality issues to federal and provincial departments and agencies;
- ° to develop new scientific knowledge and techniques to determine how pollutants are transported and deposited by the atmosphere onto ground and water surfaces and onto trees and structures;
- ° to develop new scientific knowledge and techniques relating to the processes of stratospheric pollution, including depletion of the earth's protective ozone layer.

The long-term management objectives of the Atmospheric Research Directorate's Strategic Plan (1989) are outlined in Annex A.

2.7 LINKAGES TO DEPARTMENTAL PRIORITIES

IMPLEMENTATION OF THE CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)

The Canadian Environmental Protection Act (CEPA), enacted in June 1988, provides a framework for the control of toxic chemicals throughout their life cycle in a nationally consistent manner. In addition, the Act aims to set environmental quality objectives, standards, guidelines and codes of conduct. By monitoring air quality and conducting atmospheric and inter-environmental research, Air Quality Services and Atmospheric Research directly supports the objectives and implementation of the Act.

REDUCTION OF ACID RAIN IN SENSITIVE AREAS OF CANADA

As part of the acid rain abatement program, federal-provincial agreements are in place to secure a 50% reduction in sulphur dioxide emissions from the seven eastern Canadian provinces by 1994. In order to reach this goal, Air Quality Services and Atmospheric Research's activities, in conjunction with activities within Environment Canada, are directed at:

- verifying, through a monitoring program, the adequacy of the measures put in place;
- implementing a new national program to control nitrogen oxide emissions and volatile organic compounds;
- adding to the knowledge base required for understanding the impact of acid rain on Canadian wildlife, lands, and aquatic ecosystems;
- formulating related federal policies;
- securing an agreement with the United States to reduce acid-causing emissions.

ENSURE CANADA IS ABLE TO DEAL WITH THE ENVIRONMENTAL CHANGES PRODUCED BY CHEMICAL ALTERATIONS TO THE ATMOSPHERE

With its input into climate change monitoring and climate research, Air Quality Services and Atmospheric Research, in cooperation with the Canadian Climate Centre, plays an important role in providing the necessary monitoring, research, public education, and information/advice to policy makers on the changing composition of the atmosphere and the global climate.

**IMPROVE THE DEPARTMENT'S ENVIRONMENTAL EMERGENCY RESPONSE
CAPABILITY**

Air Quality Services and Atmospheric Research coordinates the Environmental Emergency Response Program which lends support to agencies providing environmental emergency services. It does this by improving ongoing preparedness to better respond to major pollution emergencies ranging from toxic air releases to marine spills, and by developing, implementing and testing advanced tracking, monitoring and communications systems for emergency applications.

2.8 LINKAGES WITH INTERNAL AND EXTERNAL AGENCIES

2.8.1 INTERNAL

Interdisciplinary research is essential, considering the scope and the complexities of the field. Accordingly, the sub-activity interfaces with several agencies both within and outside Environment Canada.

AES is a highly integrated organization as indicated by its description as a single service (Exhibit 2.1). Air Quality Services and Atmospheric Research activities are an integral part of other programs of AES. Section 2.20 further elaborates these linkages.

WEATHER SERVICES

The Meteorological Services Research Branch carries out research and development in support of the prediction services of AES for weather, sea-state, ice and other environmental elements. Air Quality and Atmospheric Research conducts research into aerospace meteorology, numerical forecasting models, forecast research and cloud physics. This research is elaborated in section 1.21.

CANADIAN CLIMATE PROGRAM

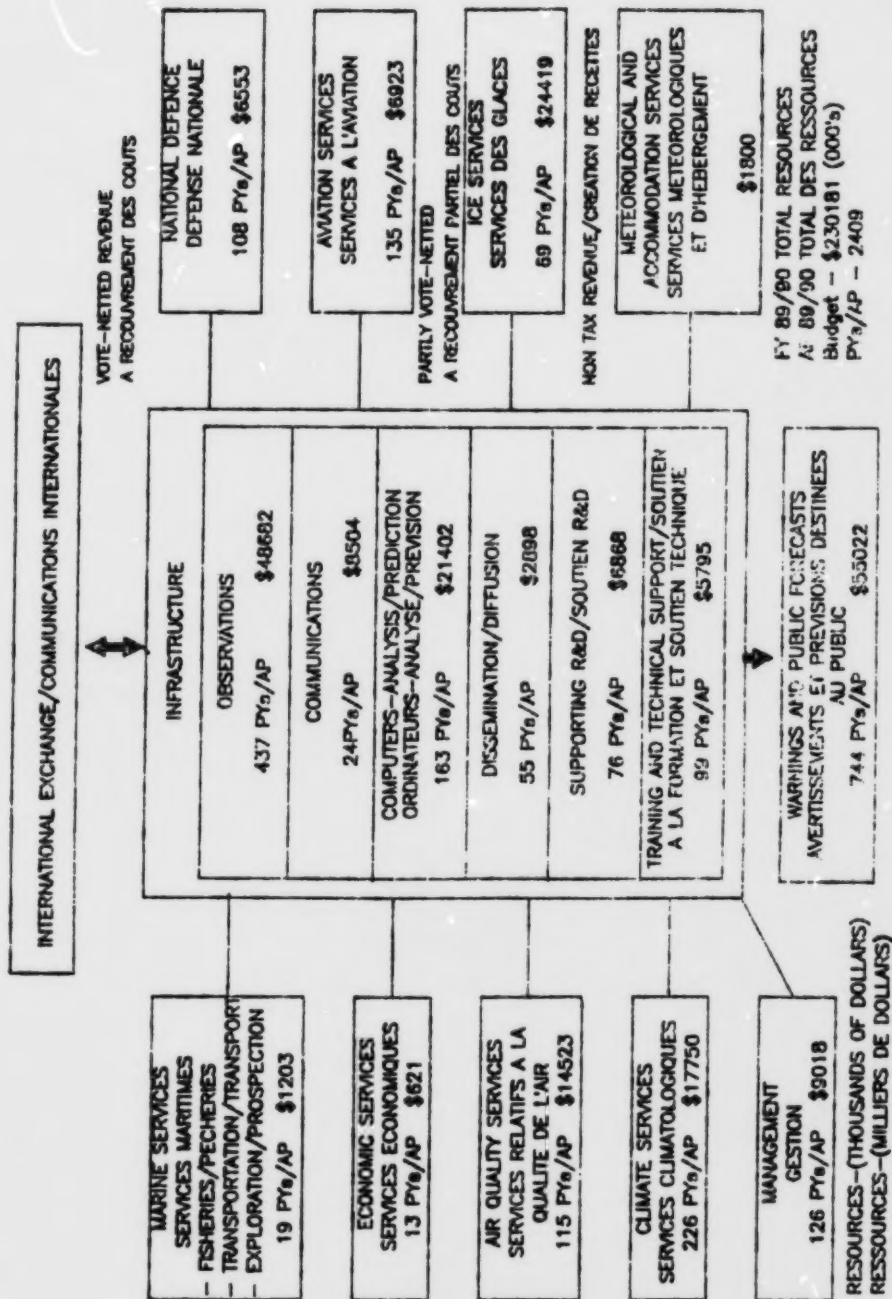
One of the functions of the Air Quality Services and Atmospheric Research is to monitor and study concentrations of critical gases in the atmosphere and their exchange process. This work focuses on radiatively active gases (e.g. greenhouse gases) that affect climate. The information provides input to and a basis for verification for the General Circulation Model (GCM) work the Canadian Climate Centre.

CONSERVATION AND PROTECTION

Conservation and Protection, the other activity of Environmental Services Program, focuses on the sound management of Canada's water, land resources, migratory birds, threatened and endangered species. Their role in developing and maintaining the knowledge base necessary for assessing the significant environmental threats arising from human activities has direct linkages with the knowledge generated by Air Quality Services and Atmospheric Research. Scientific investigations into the Long Range Transport of Air Pollutants (LRTAP) is an example of interdepartmental research efforts (see section 2.21).

ATMOSPHERIC ENVIRONMENT SERVICE SERVICE DE L'ENVIRONNEMENT ATMOSPHERIQUE 1989-1990

"A SINGLE SERVICE" / "SERVICE POLYVALENT"



Source: AES Program Digest 1989-1990

STATE OF THE ENVIRONMENT (SOE) REPORTING

The purpose of the State of the Environment Report is to present a macro-picture of environmental conditions and recent trends based on up-to-date scientific assessments, by integrating interdepartmental and intradepartmental databases. The monitoring and research activities of Air Quality Services and Atmospheric Research contribute directly to the SOE reports.

2.8.2 UNIVERSITIES

AES encourages the development of atmospheric research in Canadian universities primarily by providing funding for the Science Subvention Program and Industrial Research Chairs.

The Science Subvention Program

This granting program supports university research in the field of atmospheric science in order to build up a knowledge base. It provides 30% of total research support to the major centers of atmospheric research in Canada, with NSERC providing the remainder.

Industrial Research Chairs

AES and NSERC jointly provide the funds for four Industrial Research Chairs. Each chair consists of two academic positions:

McGill	Climate Research
York	Atmospheric Chemistry
Dalhousie	Climate Change
Dalhousie	Marine Meteorology

2.8.3 EXTERNAL RELATIONS

Air Quality Services and Atmospheric Research has many linkages and interactions with other federal and provincial agencies, international organizations, countries and the private sector. These interactions are both formal, such as through committees or memorandums of understandings, and informal, such as joint research with other agencies or countries. Some examples of these interactions are:

HEALTH AND WELFARE

Radioactivity is measured at 23 sites for Health and Welfare Canada (Exhibit 2.2). Air Quality Services and Atmospheric Research played a significant role during the aftermath of the Chernobyl disaster.

WORLD OZONE DATA CENTRE

At the request of the World Meteorological Organization, AES manages the World Ozone Data Centre.

LRTAP CO-ORDINATION

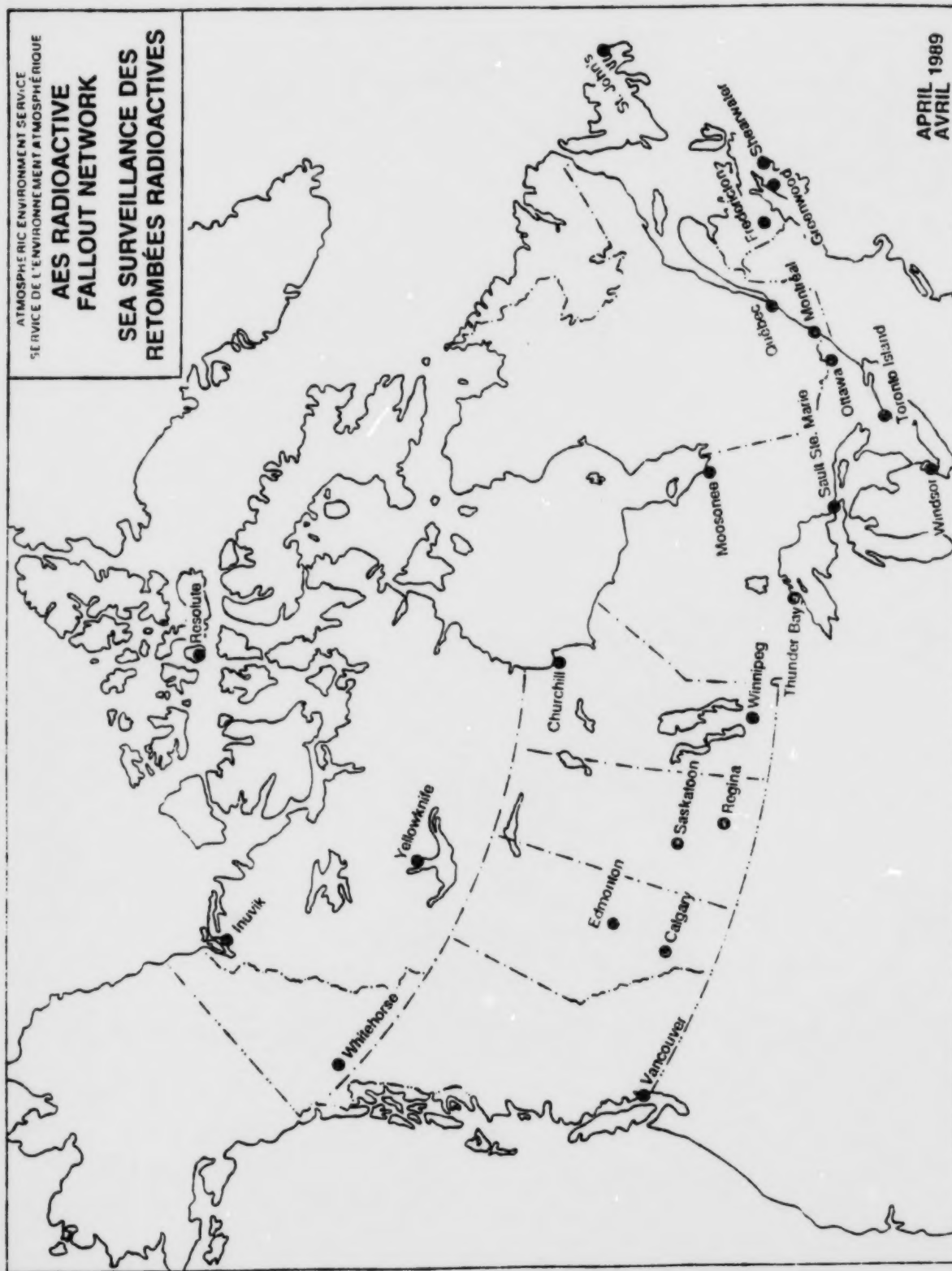
Canada-U.S. and federal-provincial research projects on acid rain, ground-level ozone and associated LRTAP issues are co-ordinated with the appropriate agencies. Related advice and knowledge, and evaluation of existing or proposed research projects are provided to policy-makers from these agencies.

AERIAL APPLICATION OF PESTICIDES

This study, in collaboration with J.D. Irving Ltd., the Province of New Brunswick and the National Research Council, gathers data to assess the accuracy of prediction models with respect to target deposits and the setting of buffer zones.

EULERIAN MODEL OF EVALUATION FIELD STUDY

This study gathers data on atmospheric chemistry close to the earth's surface, and vertically. It is a joint effort of scientists from the Province of Ontario, the United States of America and the Federal Republic of Germany.



Source: AES Program Digest 1989-1990

EXHIBIT 2.2

HUDSON'S BAY LOWLANDS EXPERIMENT

The purpose of this project is to examine the extent to which Canada's wetlands contribute to the global methane budget. It is conducted in collaboration with NASA (USA), the Canadian Institute for Research in Atmospheric Chemistry, the National Research Council, Department of Fisheries and Oceans, Agriculture Canada, National Water Research Institute, Canadian Centre for Remote Sensing and a number of universities, including McGill, Guelph, York and McMaster.

CAMANCHACA PROJECT

The purpose of this project is to extract drinking water from fog in Chile. It is being carried out by Air Quality Services and Atmospheric Research in collaboration with the International Development Research Centre and the World Meteorological Agency.

COMPARE PROJECT

COMPARE is an international project, chaired by Canada, to compare the performance of forecast models. Seventy modelers and modelling groups from around the world will participate culminating in an international scientific meeting in Montreal in 1991.

2.9 ORGANIZATIONAL STRUCTURE

Exhibit 2.3 illustrates the organization structure by sub-activity (SA 1) and sub-sub-activity (SA 2).

Exhibit 2.4 illustrates the functional organization. There is a relationship between organizational structure and the five program components (sub-activities) illustrated in Exhibit 2.3, although they do not correspond exactly. For program support, efficiency, and effectiveness purposes, certain "common service" directorates have been created within AES.

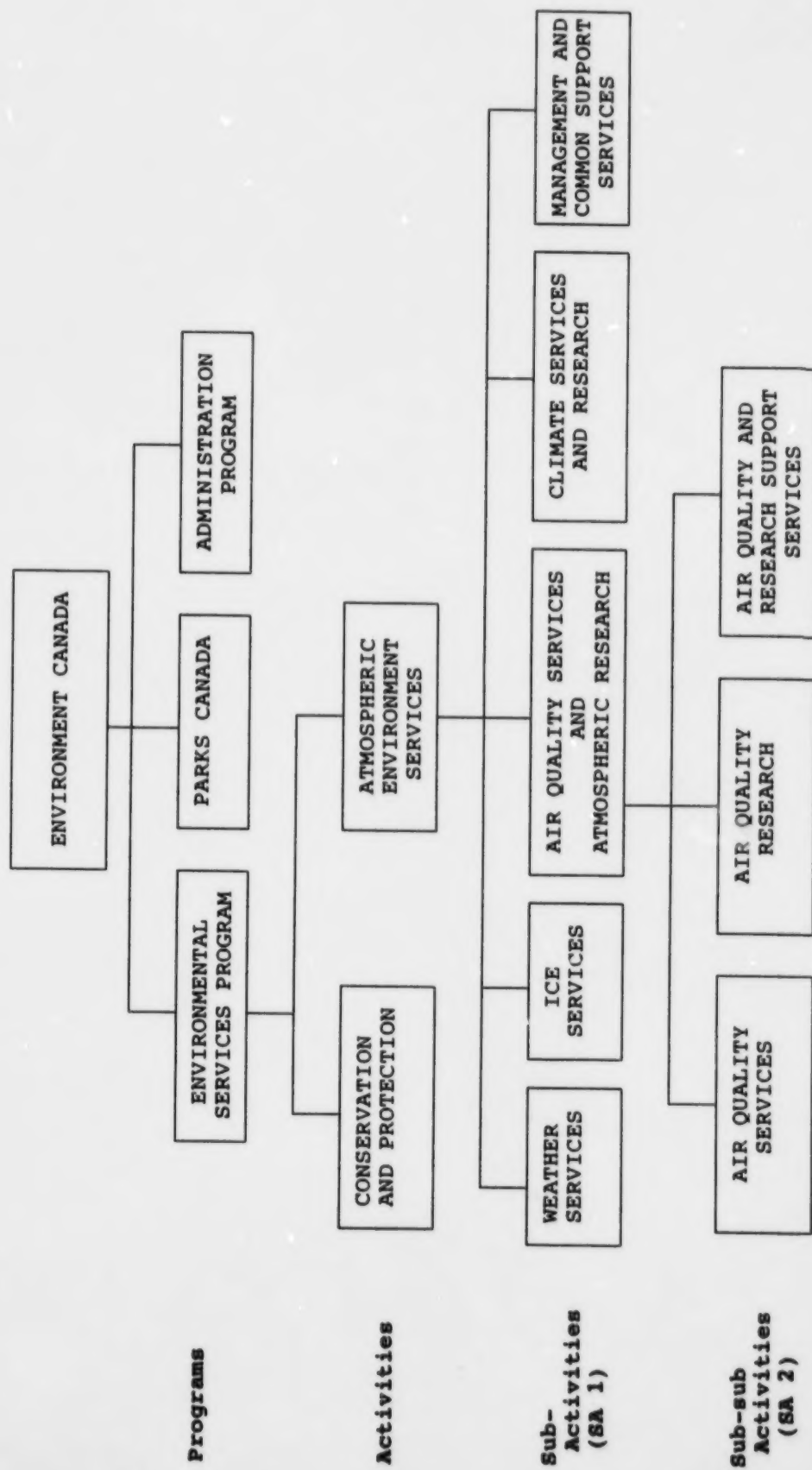
2.10 MANAGEMENT OF THE RESEARCH SCIENTISTS POPULATION

The classification for Research scientists (RES) is incumbent-oriented, i.e. their classification is not related to their job description but is related to their performance as measured by their scientific productivity, their creativity, their influence and the recognition of their work by their peers. Line managers are involved in the classification of their research scientists.

Three committees exist to assist managers and to formalize decisions:

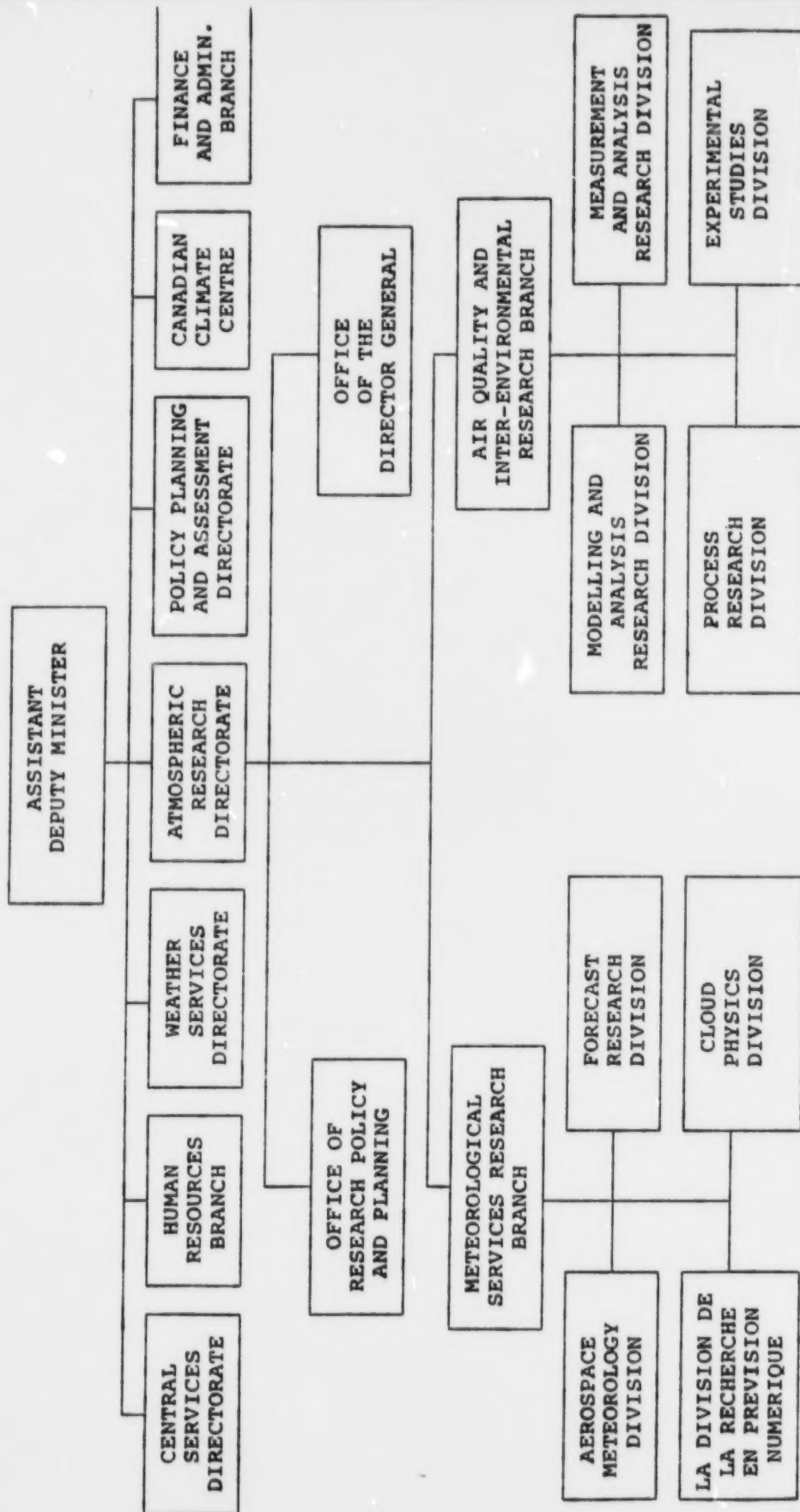
- Inter-departmental Advisory Committee for the Scientific Research Group
- DOE Committee for the Scientific Research Group
- AES Committee for the Scientific Research Group

The Director General for Atmospheric Research Directorate is responsible for the operation of the AES Committee. Annex B outlines the responsibilities of the Director General.



SEPTEMBER 1990

FUNCTIONAL ORGANIZATION STRUCTURE



ARD Operations are centred at the AES Headquarters building in Downsview, Ontario, with the exception of La Division de la Recherche en Prevision Numerique which is located in Montreal.

SEPTEMBER 1990

2.11 BASIC SERVICE DEFINITION

AES provides basic services required for "public safety and security including sovereignty, environmental protection, emergency services, protection of livelihood and international obligations."

Basic services provided by Air Quality Services and Atmospheric Research have been defined as "the provision of information to contribute to the health and safety of Canadians by ensuring that accurate and timely information on the quality of the air is available." In addition, cooperation and coordination with provincial air quality agencies and international involvement in air quality, stratospheric ozone depletion, transboundary air pollution and acid rain have become an essential part of the AES core services.

2.12 PRODUCTS OF BASIC AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH

AIR QUALITY OBJECTIVES AND STANDARDS

Scientific and technical support sufficient to determine national air quality objectives, standards, and guidelines required under the Canadian Environmental Protection Act (CEPA) are provided.

AIR QUALITY DATA ON A NATIONAL AND INTERNATIONAL SCALE

The national reference air quality network, generically called CAPMoN (Canadian Air and Precipitation Monitoring Network) consisting of at least one station in each province and territory, provides a common national standard for instrumentation, quality assurance and quality control to satisfy obligations specified by the World Meteorological Organization.

In addition, AES operates a number of additional stations in different areas of the country to monitor the transboundary fluxes of pollutants.

To ensure quality standards for global ozone data, AES maintains an international Brewer spectrophotometer calibration facility for the calibration of all spectrophotometers world-wide.

NATIONAL AIR QUALITY ARCHIVES

To maintain official records of Canadian air quality, AES operates a national archive of regional (non-urban) air quality measurements including data received in standard format from provincial agencies, universities and private sources. An annual air quality data summary is produced. This represents the federal contribution to a joint federal/provincial/private sector agreement.

An air quality climatology for Canada is produced on an annual basis so that problem areas and trends can be identified.

In accordance with the Vienna Convention for the Protection of the Stratospheric Ozone layer, AES operates the World Ozone Data Centre for the World Meteorological Organization to archive global ozone data from ground-based measurement stations.

ADVICE AND INFORMATION ON FEDERAL ENVIRONMENTAL POLICIES

Research and development is carried out to improve knowledge on the physical and chemical processes in the atmosphere. Furthermore, associated constituents supporting priority issues such as acid rain, toxic chemicals, and ozone, are also studied.

Scientific leadership for the research and monitoring aspects of the LRTAP program is provided, including coordination of the federal programs with those of other countries, the provinces, universities, and industries.

Policy advice is given on pollution control, international obligations and compliance with signed pollution reduction agreements. Scientific advice and consultation on atmospheric matters relating to the international and interprovincial exchange of airborne pollutants, including chemical transformation and deposition processes, is provided to government agencies and, where necessary, to industrial companies to achieve reductions in transboundary pollution.

Scientific work is carried out and policy advice is provided on ozone layer-depleting chemicals.

An acid rain report is made available to the public, weekly.

SERVICE DURING ENVIRONMENTAL EMERGENCIES

Predictions of dispersion and movement of toxic gases and particles emitted into the atmosphere in the event of environmental emergencies are provided, on request, to federal, provincial, and local emergency agencies to enhance health and safety protection. A basic capability to provide these predictions is maintained at each regional office.

SUPPORT FOR ENVIRONMENTAL ASSESSMENT REVIEW PROGRAM

A basic capability to allow forecasts and assessments of the dispersion of pollutants to meet the air quality requirements under the Environmental Assessment Review Program is maintained at each AES regional office.

MONITOR WEATHER MODIFICATION ACTIVITIES

AES has been designated the responsibility, under legislation, to monitor and report on all activities aimed at artificially changing the weather in Canada. Scientific and policy advice and administration services are provided, as required, under the Weather Modification Information Act and the U.S./Canada Weather Modification Agreement.

2.13 COST RECOVERY

AES may provide special services if the private sector is unable or unwilling to meet the demand, or if that course of action is judged by the Minister to be in the public interest. Products and services beyond the AES basic level of services are subject to full cost recovery in accordance with Treasury Board policies and the AES Schedule of Charges.

Examples of Air Quality Products and Services that are subject to cost-recovery are:

- analyses from the National Air Quality Archive other than annual data summaries and those provided under either bilateral, federal/provincial, or partnership agreements;
- all advice and guidance, not available from the private sector, is provided in accordance with the AES policy on consultation and special forecasts (clients are charged for consultations in excess of 10 minutes);
- specialized air quality modeling for which a private sector capability does not exist;
- air quality publications other than those included in the basic level of service.

2.14 CLIENTS/PARTNERS/STAKEHOLDERS

The primary clients of Air Quality Services and Atmospheric Research are federal and provincial decision-makers, and the Canadian public. Within Environment Canada, the Canadian Meteorological Centre and the Canadian Climate Centre rely on information generated by the program. Canadian universities benefit from the program through the science subvention program and research grants. The program has several formal and informal partners in cooperative research which are outlined in section 2.8.3.

In addition, the private sector utilizes research findings for commercial purposes and for the development of environmental technologies.

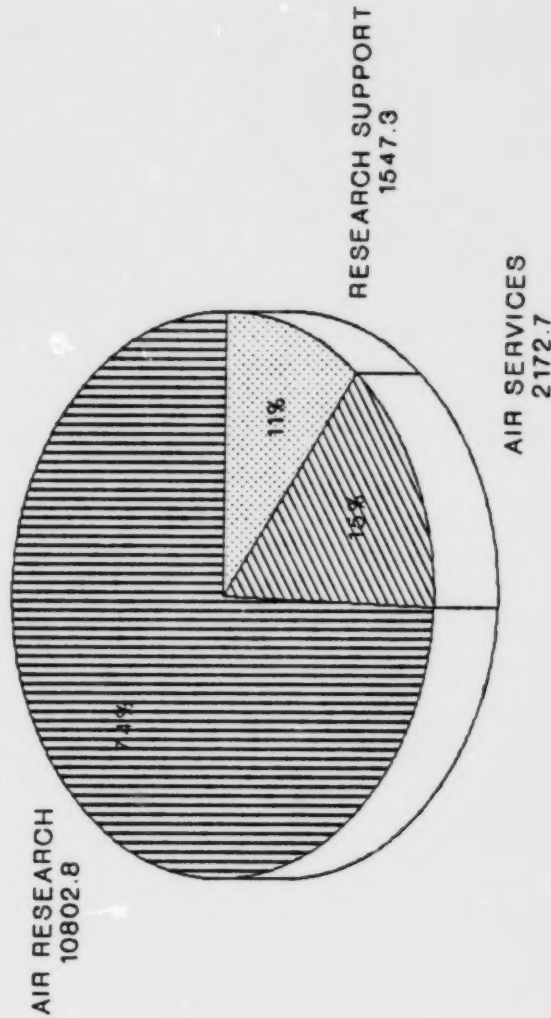
2.15 BUDGET

AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH
1989-1990 BUDGET BY SUB-SUB-ACTIVITY
(\$000)

SUB-SUB-ACTIVITY	PY	SALARY	O & M	CAPITAL	G&C	TOTAL
AIR QUALITY SERVICES	21.3	1232.9	439.8	500.0		2172.7
AIR QUALITY RESEARCH	84.2	4926.9	3879.9	1682.0	314.0	10802.8
AIR QUALITY & RESEARCH SUPPORT SERVICES	9.5	726.3	629.0	192.0		1547.3
TOTAL	115.0	6886.1	4948.7	2374.0	314.0	14522.8

SOURCE: AES PROGRAM DIGEST 1989-90

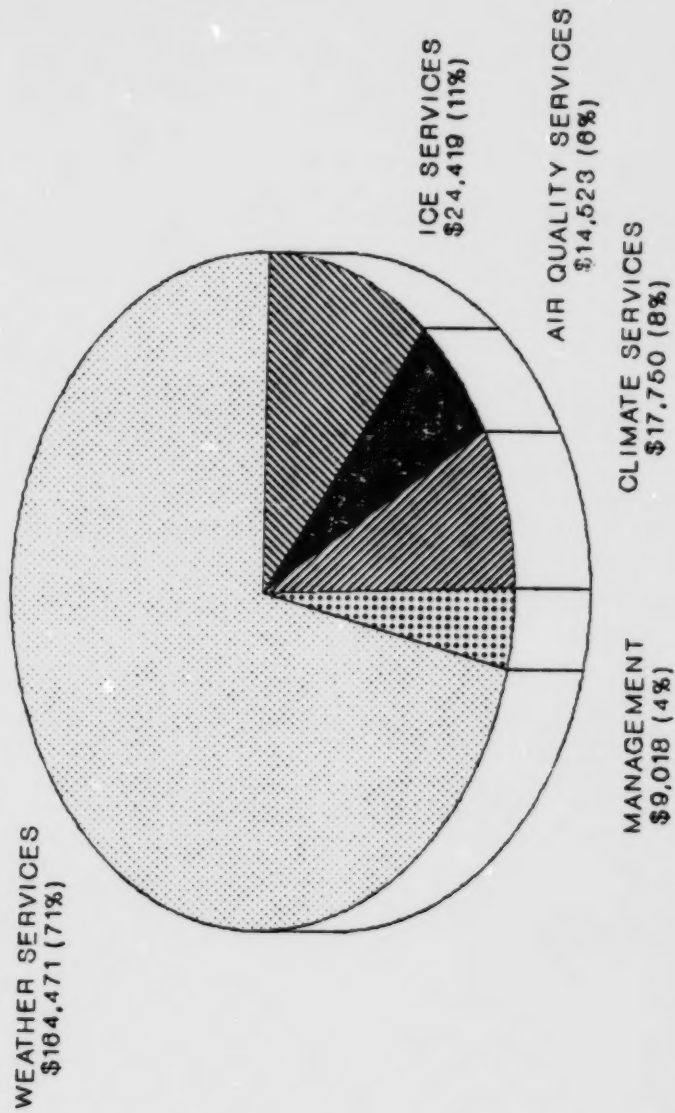
AIR QUALITY SERVICES AND RESEARCH BUDGET BY SUB-SUB-ACTIVITY



Source: AES PROGRAM DIGEST 1989-90
(BUDGET TOTAL: \$14622.8K)

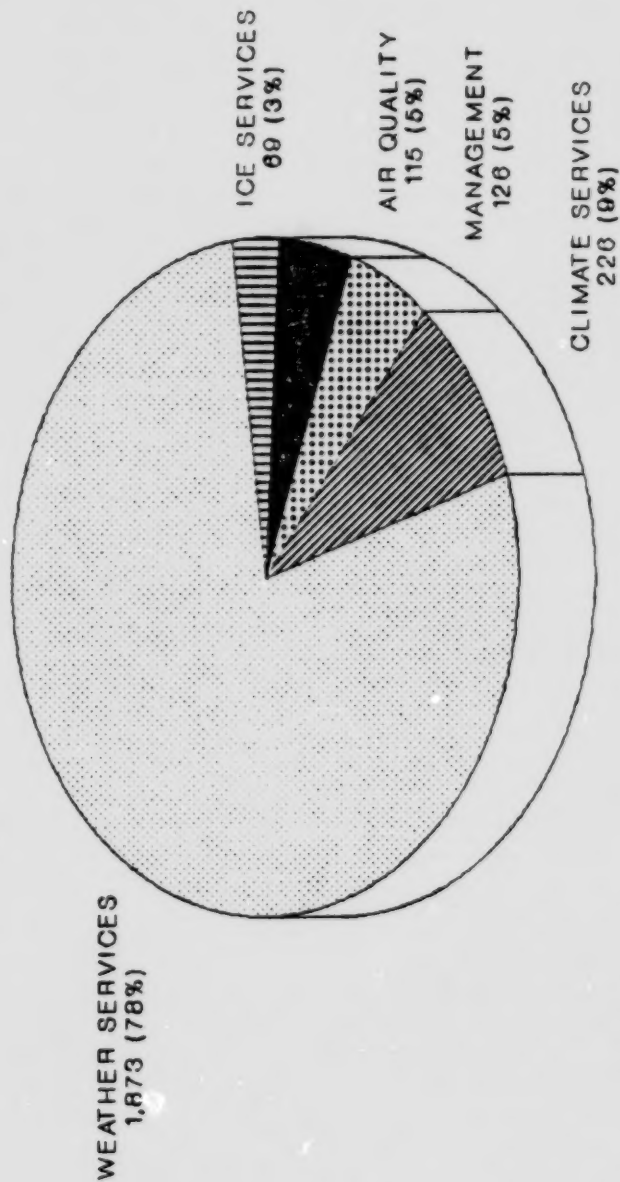
TOTAL BUDGET BY SUB-ACTIVITY

ALL SERVICES, TOTAL BUDGET-\$23,018,(000)



Source: AES Program Digest 1989-90

PERSON YEARS BY PROGRAM SUB-ACTIVITY ALL SERVICES, TOTAL PYS-2,409



SOURCE: AES PROGRAM DIGEST 1989-90

2.16 PANEL ON ENERGY RESEARCH AND DEVELOPMENT (PERD)

With the exception of nuclear fission, PERD is responsible for coordinating and implementing federal research and development for energy supply and end-use sectors. The purpose of PERD is to assure a scientific and technological base for a diversified economically and environmentally sustainable energy economy. Environment Canada receives approximately \$7.1 million of the total \$89.1 million PERD (1989) funds. The following are examples of PERD-funded projects:

- design information and measurement technology
- CO₂ flux measurement

2.17 FACILITIES

Air Quality Services and Atmospheric Research are located in the AES Headquarters building in Downsview, Ontario. The only component housed entirely outside of Downsview is la Division de la recherche en provision numérique, which is located in Montréal. In addition, Air Quality Service and Atmospheric Research operates:

- Centre for Atmospheric Research Experiments in Egbert (Ontario)
- Weather Radar Research Station in King Township (Ontario)
- Arctic Air Quality Laboratory in Alert (NWT)
- Great Lakes Research Station in Point Petre (Ontario)
- Canada-wide network of stations for monitoring pollutants in air and precipitation
- Fleet of specialized mobile laboratories to support field experiments
- Two research aircraft operated by NAE and CCRS

2.18 KEY PLANS FOR AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH (1989-90)

Air Quality Services and Atmospheric Research has several key objectives, including:

- improved response to environmental emergencies;
- ozone layer protection;
- partnerships with universities;
- establishment of a national chemistry data-base (in cooperation with the United States and the provinces);
- air quality research;

2.19 LONG-TERM STRATEGIC ISSUES

The long-term strategic issues include:

- rejuvenation of the science base;
- translation of science into policy;
- technology transfer;
- international and bilateral relations.

2.20 LOGIC CHART

The logic chart illustrates the linkages between the activities, outputs, effects, and impacts of a program. The chart (Exhibit 2.8) highlights how the program's objectives are achieved.

2.21 ACTIVITIES OF AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH

For the purposes of this analysis, Air Quality Services and Atmospheric Research has three main activities. These activities include:

- conducting and supporting scientific research, developing models, procedures, and systems for forecasting weather elements and environmental parameters;
- conducting and supporting scientific research and development on the physics and chemistry of the troposphere and stratosphere;
- monitoring the troposphere and stratosphere.

It is difficult to effectively summarize the complexities of these research activities. For purposes of simplicity, however, the main research focus is summarized for each activity.

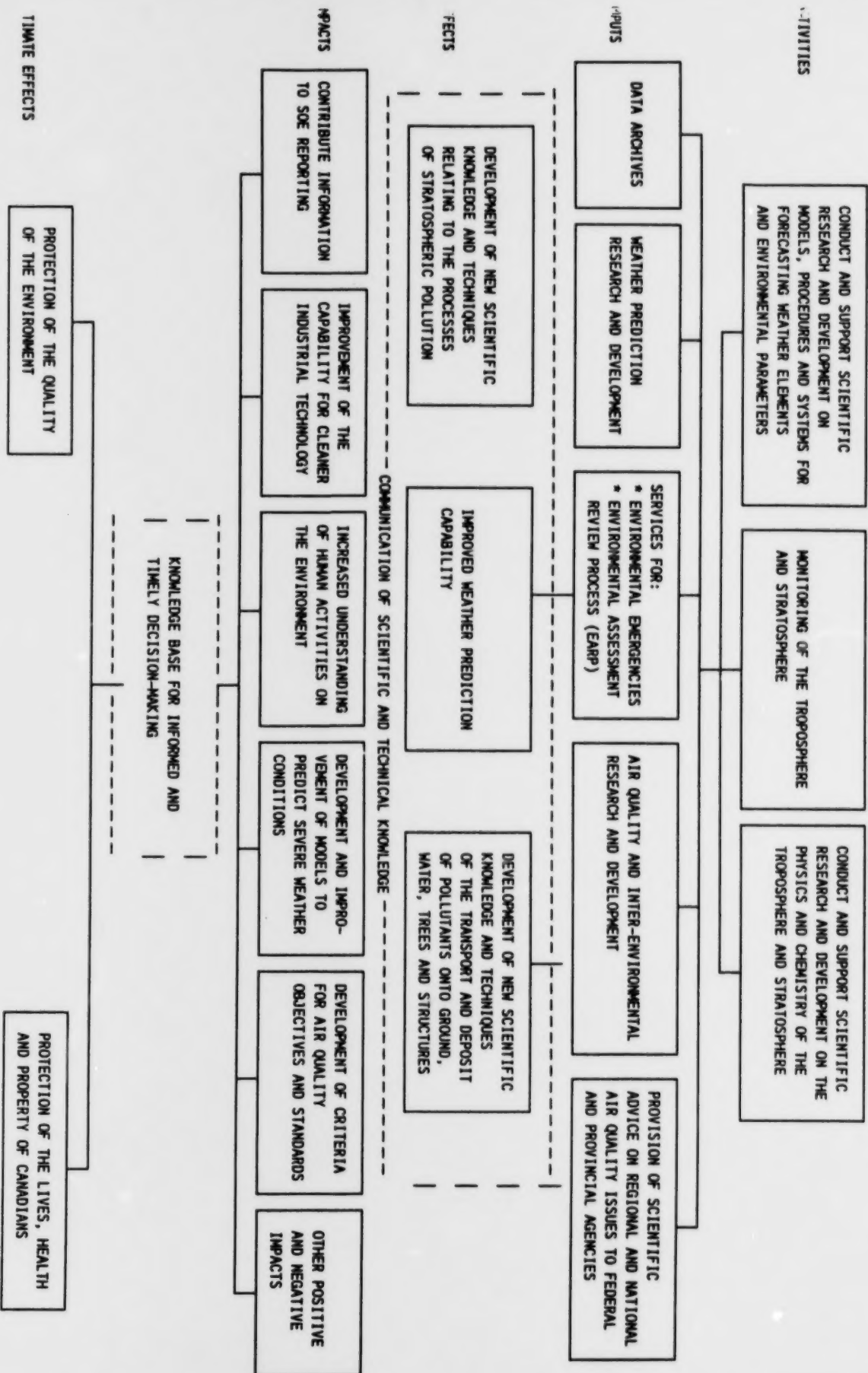
2.21.1 CONDUCT AND SUPPORT SCIENTIFIC RESEARCH AND DEVELOPMENT OF MODELS, PROCEDURES AND SYSTEMS FOR FORECASTING WEATHER ELEMENTS AND ENVIRONMENTAL PARAMETERS

The Meteorological Services Research Branch carries out this activity in four divisions (Annex C provides a detailed description of each division):

LA DIVISION DE LA RECHERCHE EN PREVISION NUMERIQUE

- enhancement of operational models
- numerical analysis techniques
- data assimilation

LOGIC CHART
AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH



- physical parameterization
- model development
- Compare project (compare the performance of forecast models)

CLOUD PHYSICS

- the role of clouds on the chemistry of atmosphere and precipitation
- the role of clouds and the precipitation process on the development of severe convective storms and extra-tropical cyclones
- the use of weather radar for weather forecast operations and atmospheric research

FORECAST RESEARCH

- artificial intelligence
- computerized "forecast production assistant"
- statistical weather element prediction
- environmental prediction

AEROSPACE METEOROLOGY

- wind engineering
- satellite operations
- development of satellite readout stations

**2.21.2 CONDUCT AND SUPPORT SCIENTIFIC RESEARCH AND
DEVELOPMENT ON THE PHYSICS AND CHEMISTRY OF
THE TROPOSPHERE AND STRATOSPHERE**

The Air Quality and Inter-Environmental Research Branch conducts this activity. The main focus of research of this branch is:

STRATOSPHERIC OZONE

- monitoring
- modeling
- instrumentation
- project Stratoprobe
- World Ozone Data Centre

GREENHOUSE GASES

- flask sampling program
- continuous monitoring program
- Hudson's Bay Lowlands Methane Project
- Global Climate - Carbon Cycle Model

ACID RAIN AND REGIONAL SMOG (LRTAP)

- modeling
- monitoring
- process studies

ENVIRONMENTAL EMERGENCY RESPONSE

- emergency preparedness coordination
- real-time emergency response
- emergency communications

2.21.3 MONITORING OF THE TROPOSPHERE AND STRATOSPHERE

STRATOSPHERIC OZONE

Air Quality Services operates the Canadian network of ozone measurement stations at Toronto, Saskatoon, Goose Bay, Edmonton, Churchill, Resolute and Alert (Exhibit 2.9).

GREENHOUSE GASES

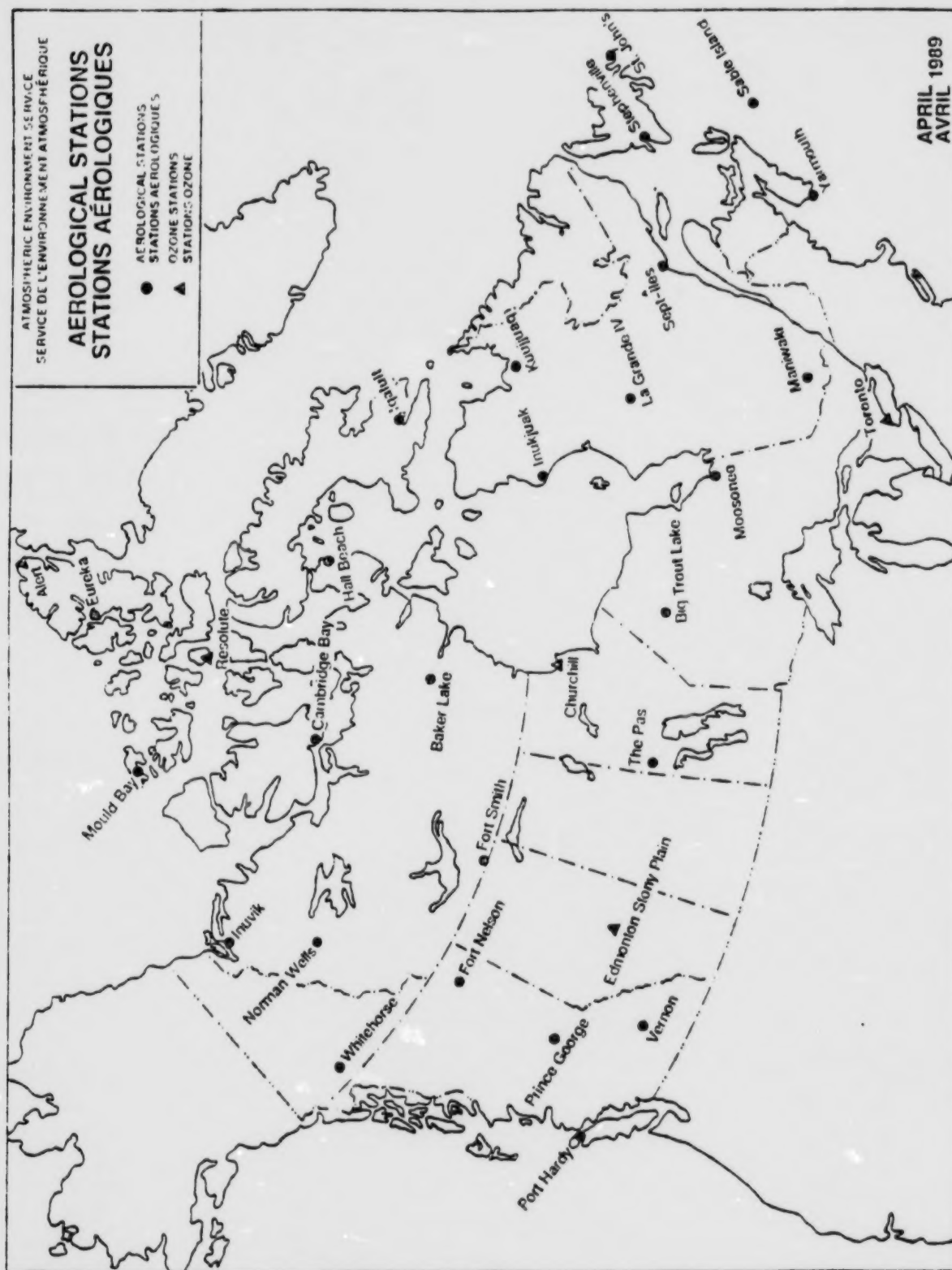
CO₂, CH₄, O₃ are three of the greenhouse gases now being measured using infrared, gas chromatographic and spectrophotometric techniques. Ancillary measurements identify the origin of air masses. Air Quality Services uses:

- flask sampling, useful in identifying trends and annual cycles. Cooperative flask sampling programs have been initiated at Alert with other agencies and measurements have been extended to isotopes of carbon, oxygen and other greenhouse gases, including CFCs.; and
- continuous monitoring, useful for obtaining more accurate measurement of annual average concentrations, of the magnitude of the amplitude of the annual cycles. Continuous monitoring is also useful for identifying sources and sinks, and eliminating data influenced by local sources.

ACID RAIN AND REGIONAL SMOG: CANADIAN AIR AND PRECIPITATION MONITORING NETWORK (CAPMON)

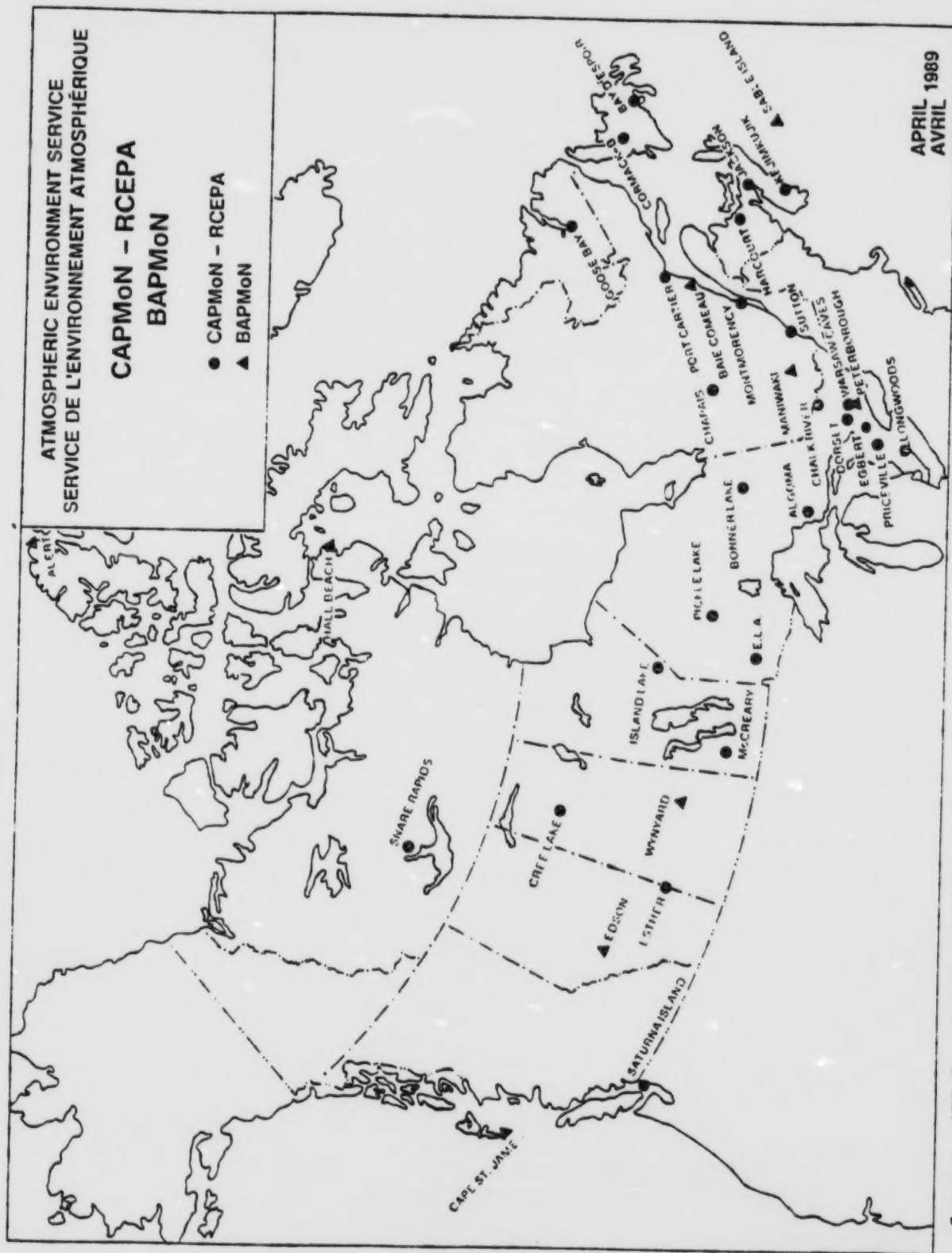
The CAPMON network, consisting of 24 stations, was established in 1983 to conduct regional monitoring of air and precipitation chemistry (Exhibit 2.10). Principal focus areas include:

- precipitation chemistry monitoring
- air chemistry monitoring
- ground level ozone monitoring
- Eulerian Model Evaluation Field Study (EMEFS)
- NOx monitoring
- pH in precipitation
- volatile organic compounds



Source: AES Program Digest 1989-1990

EXHIBIT 2.9



2.22 OUTPUTS

Air Quality Services and Atmospheric Research activities produce five main outputs:

- ° weather prediction research and development;
- ° air quality and inter-environmental research and development;
- ° services for environmental emergencies and environmental assessment review process (EARP);
- ° data archives;
- ° provision of scientific advice on regional and national air quality issues to federal and provincial agencies.

These outputs are explained in Section 2.12.

2.23 EFFECTS

The immediate effects of the provision of these outputs include:

- ° the development of new scientific knowledge and techniques relating to the processes of stratospheric pollution;
- ° the development of new scientific knowledge and techniques of the transport and deposit of pollutants onto ground, water, trees and other structures; and,
- ° improved weather prediction capability.

These effects directly reflect the objectives of the program outlined in section 2.6.

2.24 COMMUNICATION OF KNOWLEDGE

A crucial linkage in this logic chart is the communication of this scientific and technical knowledge. The success of the program depends on how effectively the scientific and technical knowledge that program generates is conveyed to its clients. The scope of this communication is wide. It involves the presentation of findings at conferences and symposiums, publications in scientific journals, the accessibility and use of databases by internal and external agencies, and the timely advice and consultation given to decision-makers and the Canadian public.

2.25 KNOWLEDGE BASE FOR DECISION-MAKING

By using the knowledge base generated by the activities of Air Quality and Atmospheric Research, there is an increased capability for informed and timely decision making that lead to the ultimate effects of the program to protect the quality of the environment and to protect the lives, health and property of Canadians.

2.26 IMPACTS

Like all research activities, the knowledge generates a broad range of socioeconomic impacts. Some examples are:

POSITIVE IMPACTS

- contributes information to SOE reporting
- development of cleaner industries
- increased understanding of the impact of human activities on the quality of the environment
- development and improvement of models to predict weather conditions
- development of air quality objectives and standards.

NEGATIVE

- industrial adjustment to newly regulated manufacturing processes.

ISSUES

3.1 RATIONALE ISSUES

ISSUE: LEGITIMACY	INDICATORS	DATA COLLECTION OPTIONS
1. Do the scientific activities undertaken by Air Quality Services and Atmospheric Research constitute a legitimate role for the federal government at this time?	• client/stakeholder/partner opinion • program manager opinion • expert opinion	• client survey • program manager survey • focus group • case studies
ISSUE: POLICY RELEVANCE		
2. Do the conditions which gave rise to Air Quality Services and Atmospheric Research still prevail?		
3. Is the program consistent with and does it promote the principles and policies articulated in the S&T Decision Framework?		
4. In what manner and to what extent does the program reflect priorities outlined in INNOVATION?		
5. What will be the role of Air Quality Services and Atmospheric Research in future policy initiatives?		
6. What role does Air Quality Services and Atmospheric Research play in orienting environmental technology?		
ISSUE: STRUCTURE		
8. Are the program design, mix of activities/outputs and level of effort such that it is reasonable and probable to expect that substantial benefits will accrue from the program and that these will lead to the intended program results?		
9. Does the program have a clearly defined clientele?		

3.2 CLIENT RELEVANCE ISSUES

ISSUE: CLIENT RELEVANCE	INDICATORS	DATA COLLECTION OPTIONS
1. To what extent are the clients/ stakeholders/partners satisfied that the program is producing or is likely to produce results that can be useful to them?	• client opinion • program manager opinion	• client survey • program manger survey • focus group
2. Are the clients' needs clearly identified?		
3. Is the research reaching the client in a timely and consistent manner?		

3.3 PROGRAM MANAGEMENT ISSUES

ISSUE: PROGRAM MANAGEMENT	INDICATORS	DATA COLLECTION OPTIONS
1. Is the type, level and distribution of resources within the program adequate in relation to the objectives of the program.	• client/stakeholder/partner opinion • program manager opinion • Treasury Board's opinion on the program's compliance with Government policy on Major Surveys	• client survey • program manager survey • Treasury Board personnel survey
2. Is the size, structure, and organization of the program suitable?		
3. Is the management style and working environment appropriate and conducive to success?		
4. Has the element of risk been adequately considered in the decision-making process concerning program delivery?		
5. Has Air Quality Services and Atmospheric Research become the lead agency for atmospheric research?*		
6. Is there an optimal level of participation of the private sector in the provision of special services?		
7. Does strategic planning effectively reflect the needs of the clients and the objectives of the department?		
8. What productivity improvements, including technological changes and revisions to existing levels of services, are being realized?*		

* MAJOR SURVEY REQUIREMENT

3.4 OUTCOME ISSUES

ISSUE: OBJECTIVES ACHIEVEMENT	INDICATORS	DATA COLLECTION OPTIONS
1. Have the program objectives been clearly identified?	• client/partner/ stakeholder opinion • peer satisfaction with quality of research • program manager opinion • positive cost-effectiveness analysis	• client survey • program manager survey • peer review • citation analysis • focus group • case studies • expert opinion • cost-effectiveness analysis
2. Has the program met its objectives in terms of timeliness, budget and results anticipated?		
3. Is the ARD Tactical plan executed in a reasonable time-frame?		
4. Is the research effectively prioritized?		
5. Do clients have an input into this prioritization process?		
6. Does air quality monitoring provide an adequate level of service?		
7. Does the program adequately support the Environmental Assessment Review Process (EARP)?		
8. Does information gathered by Air Quality Research provide useful inputs to general circulation models?		
9. Is the Emergency Preparedness program adequately supported by the program?		
10. Is Canada fulfilling its international obligations for air quality monitoring and atmospheric research?		
11. Have performance indicators and success criteria been developed for air quality services? Are Operational Planning Framework (OPF) performance criteria a reliable measure of program success?		
12. Is there a satisfactory mix of basic and mission-oriented research within Air Quality Services and Atmospheric Research? Is there a critical mass of basic research performed in universities to support applied research within the program?		

3.4 OUTCOME ISSUES (CON'T)

ISSUE: OUTCOME	INDICATORS	DATA COLLECTION OPTIONS
13. How successful has Air Quality Services and Atmospheric Research been in technology transfer?	• client/partner/ stakeholder opinion • program manager opinion • expert opinion • peer satisfaction with quality of research • program manager opinion • positive cost-effectiveness analysis • Treasury Board's opinion on the program's compliance with Government policy on Major Surveys	• client survey • program manager survey • focus group • Treasury Board personnel survey • peer review • citation analysis • cost-effectiveness analysis
14. Is there effective communication and exchange of information between Air Quality Services and Atmospheric Research and: • other units within Environment Canada • clients • provincial agencies • international agencies • general public?		
ISSUE: IMPACTS AND EFFECTS		
15. What have been and/or expected to be the broad impacts and effects (both positive and negative) of the program? In particular, to what extent does the program contribute to the broad objectives set out in the Decision Framework?		
16. Have collaborative efforts with Statistics Canada been established for the development of environmental indicators?*		

* MAJOR SURVEY REQUIREMENT

3.4 OUTCOME ISSUES (CON'T)

ISSUE: IMPACTS AND EFFECTS (CON'T)	INDICATORS	DATA COLLECTION OPTIONS
17. Do data collected by Air Quality Services and Atmospheric Research duplicate information available in other federal/provincial departments, the private sector or other international organizations?*	• client/partner/stakeholder opinion • program manager opinion • expert opinion • peer satisfaction with quality of research • program manager opinion • positive cost-effectiveness analysis • Treasury Board's opinion on the program's compliance with Government policy on Major Surveys	• client survey • program manager survey • focus group • Treasury Board personnel survey • peer review • citation analysis • cost-effectiveness analysis
18. Have the economic and technological development potential of Air Quality Services and Atmospheric Research been fully harnessed?*		
ISSUE: QUALITY OF WORK		
19. Is Air Quality Services and Atmospheric Research producing quality research?		

3.5 ALTERNATIVES ISSUES

ISSUE: ALTERNATIVES	INDICATORS	DATA COLLECTION OPTIONS
1. What are the possible alternatives to federal provision of Air Quality Services and Atmospheric Research?* What are the pros and cons of each alternative?	• client/partner/stakeholder opinion • program management opinion • expert opinion • Treasury Board's opinion on the program's compliance with Government policy - Major Surveys	• client survey • program manager survey • focus group • Treasury Board personnel survey
2. Have opportunities for contracting-out, make-or-buy, cost-recovery, privatization and joint-management of activities been fully explored?*		
3. Are there opportunities to increase the level of cooperation on research with: a. clients b. other federal departments c. universities d. provinces e. private industry f. international agencies g. other countries?		

* MAJOR SURVEY REQUIREMENT

EVALUATION CONSIDERATIONS

4.0 EVALUATION DESIGN

4.1 INTRODUCTION

Program evaluation is a disciplined review of the efficiency and effectiveness of a program. It is a strategic management tool which aims to:

- * address the priority program issues
- * measure program effectiveness in a valid and reliable manner
- * assure an objective and balanced report of the program
- * promote the use of results of evaluation to improve, modify or confirm the program to meet accountability reporting requirements.

The evaluation of this program should have a "multiple lines of evidence" approach. For example, although it is essential to examine the 'quality' of science conducted in the sub-activity, this would only be examining one part of the 'big picture' of the program. Yet, to thoroughly evaluate the program, other issues, such as the rationale, and the effectiveness of the communication of scientific information must also be examined.

Section 4.2 outlines factors that must be considered in the evaluation of Air Quality Services and Atmospheric Research. Section 4.3 examines potential methodologies for the multiple lines of evidence approach.

4.2 EVALUATION CONSIDERATIONS

Evaluating science and technology is both a complex and challenging task. This section outlines the areas that must be taken into consideration in the evaluation of Air Quality Services and Atmospheric Research.

4.2.1 THE NATURE OF SCIENCE AND TECHNOLOGY

4.2.1.1 THE MEANING OF SCIENCE AND TECHNOLOGY

Science and Technology (S&T): field of knowledge acquired by the systematic study, definition, and application of the laws governing natural and human phenomena.

Research and Development (R&D): creative work undertaken on a systematic basis to increase the stock of knowledge, or to devise new applications.

Related Science Activity (RSA): activities which complement and extend R&D by contributing to the generation, dissemination, and application of knowledge.

4.2.1.2 THE PROCESS¹

The process of research and development (R&D), beginning with the investigations of the original concept to the development of a useful product or process, is presumed to occur in discrete steps as illustrated in the following model:

BASIC RESEARCH → APPLIED RESEARCH → DEVELOPMENT

1. Adapted from THE CHALLENGE OF EVALUATING RESEARCH AND DEVELOPMENT IN THE GOVERNMENT SECTOR by W.D. Bennett and I.S. Jaswal, Department of Energy, Mines and Resources.

The three-stage model is useful for conceptualizing the process. However, there are several shortcomings:

- the relationship between the three steps is not necessarily linear. The clear distinctions made between the various stages of R&D tend to blur in actual practice.
- the implication of the model is that all new products and processes can be traced to the original basic research. However, in practice, a single scientific breakthrough at the basic research level may lead to a number of unexpected projects downstream.
- the model fails to depict the time-lags in the process.

4.2.1.3 THE RESEARCH AND DEVELOPMENT SPECTRUM

The R&D spectrum, illustrated in exhibit 4.1., highlights how research is conducted and promoted by the Federal Government.

4.2.1.4 CHARACTERISTICS OF R&D

UNCERTAINTY AND RISK

The central characteristic of R&D is the element of novelty and uncertainty since new knowledge, products, or processes, are being sought. It must be recognized that only a portion of projects will pay off in the manner anticipated; others will pay off in unexpected directions by uncovering new opportunities, whereas some other projects will be failures or will uncover new problems during their execution. Indeed, well-done research is both legitimate and relevant, even if it does not achieve its intended objectives.

Accordingly, operational control of research and development should be sufficiently flexible to permit managers to optimize benefits associated with unexpected results, rather than solely attempting to minimize risk of failure. Thus, a management system for R&D projects must make provision for uncertainty in the three significant variables of budget, project duration, and the nature of results. R&D is characterized by a greater degree of uncertainty than many other activities because these three variables cannot be defined independently.

THE RESEARCH SPECTRUM

How research is conducted/promoted by the Federal Government:

Purchased or obtained from foreign sour- ces	Conducted in- house in federal lab- oratories	Contracted-out	Funded by contri- butions -- to non-government laboratories	Funded by grants	Encouraged in non- government laboratories by: *government procurement policies *tax write-offs for research *accelerated CCA *other fiscal mechanisms	Moral suasion

- Notes:
- ° Government control over research declines steadily from left to right across the spectrum. Industry funding, industry commitment, and the probability of rapid and successful technology transfer are expected to increase from left to right as far as the double line.
 - ° Government policy promotes the performance of research by non-governmental (university or private sector) laboratories, whenever this is compatible with the national interest.
 - ° Factors which might dictate that research be retained in government laboratories include considerations of national security, the administration of justice, or absolute non-availability of private funding or support for research in strategic areas.
 - ° Characteristics of government in-house research are efficiency (assuming competent management); comparatively low socio-economic cost; high cost in terms of person years and government funds; and a relatively low contribution to developing non-government research capability.
 - ° University research in some areas is constrained by the fact that much university funding is quite short-term.

TIME

In R&D, there tends to be a longer time delay between investment of resources, particularly human resources, and achievement of expected returns, in comparison to other types of operations. Such time frames usually exceed those of the multi-year planning cycle of the government and may exceed the anticipatory time frame of the political process. The difference in planning horizons necessitates that R&D managers obtain executive recognition of the need for matching human resources to specific projects which go beyond the government's multi-year planning time-frame. Moreover, to provide assurance to the executive level regarding the progress of the long term investment, R&D activities must make use of shorter term indicators of progress and success.

THE HUMAN ELEMENT

Research is strongly person-oriented. Imagination, creativity, and innovation are fundamental to the success of R&D. Accordingly, success depends strongly on the competence, motivation, ingenuity and morale of the staff.

INCREMENTALITY

Scientific progress usually results from steady, gradual, methodical research. Progress is more often a result of small incremental advances rather than major break-throughs.

4.3 SCIENCE AND TECHNOLOGY: GOVERNMENT POLICY

4.3.1 FEDERAL STRATEGY

4.3.1.1 INNOVATION

The 1987 federal strategy for S&T, called INNOVATION, is aimed at promoting research and development and technological competitiveness by focussing federal expenditure in science and technology activities. The INNOVATION strategy has five main goals:

- industrial innovation and technology diffusion
- strategic technologies
- effective management of federal resources
- investment in human resources
- development of a science culture in Canada

4.3.1.2 DECISION FRAMEWORK

The management of research and development resources must reflect government policies that promote cooperative science and technology activities and increased expenditures in the private sector.

A decision framework, therefore, has been formulated by MOSST, which outlines overall coordination and direction to the federal government's science and technology activities. The following principles have been reflected in the Issues section of this document and should be of prime importance in the evaluation of the program development:

1. Science and technology are a vital means to support social and economic development, and other government goals.
2. In-house performance of science and technology is appropriate where it is essential for the conduct of departmental missions. Federally-funded science and technology activities should be performed in both the private sector and universities if appropriate and feasible.
3. Federal support will be used to lever increased contributions from industry and the provinces to raise the national level of R&D performance. It will favour initiatives that forge stronger linkages among the industry, university, and government sectors.

4. Effective management of federal science and technology resources can be enhanced by focusing on the purpose of activities according to three categories and related objectives:

- a. economic and regional development
- b. government missions
- c. advancement of knowledge.

4.3.2 CABINET REQUIREMENTS

As a result of the findings of the Ministerial Task force on Program Review (Nielsen Task Force), Cabinet has asked for an examination of the following issues during the evaluation study of Air Quality Services and Atmospheric Research:

- ° identify possible alternatives to the federal provision of Air Quality Services and Atmospheric Research;
- ° increase opportunities for commercialization by further contracting-out, make-or-buy, cost-recovery, privatization and joint management of activities;
- ° effect productivity improvements including technological change and revisions to existing levels of service, as well as in-house delivery;
- ° harness and promote the economic and technological potential of Air Quality Services and Atmospheric Research;
- ° determining whether Air Quality Services and Atmospheric Research is the lead agency in the research of atmospheric pollution;
- ° assessing the collaborative efforts between Statistics Canada and Air Quality Services for the development of environmental indicators.

4.3.3 TREASURY BOARD'S GOVERNMENT PROGRAM EVALUATION PLAN 1989

The Government Program Evaluation Plan (GPEP) (1989) emphasizes that the issues of program rationale, cost-effectiveness, and the quality of science should be more fully examined in future S&T evaluations.

4.4 THE NATURE OF ENVIRONMENTAL SCIENCE AND TECHNOLOGY

THE EVOLVING MANDATE OF ENVIRONMENT CANADA

The challenge for Environment Canada into the next century is to develop an anticipatory and proactive policy. Environmental science and technology is the basis of the realization of this goal.

The consolidation of the broad scientific expertise in Environment Canada is crucial. The extent to which Environment Canada has mechanisms to promote cooperation should be examined in the evaluation study.

UNDERSTANDING OF ECOSYSTEMS AS A WHOLE

Environmental issues cannot be examined in isolation. They can only be understood within the context of ecosystems as integrated wholes. A broad base of scientific knowledge is imperative for understanding the interfaces of man's activities on land, air, and water. Accordingly, a multidisciplinary approach is essential, especially in the development of models.

Since pollution knows no boundaries, environmental issues must be examined regionally, nationally, and globally. This makes the scope of environmental science and technology extremely wide-ranging. Cooperative research efforts are an integral factor in the effectiveness of environmental research.

LONG TERM TIME FRAME

It is essential to use a long term time frame when conducting environmental science and technology research, simply because there are numerous uncertainties and unknown variables which may impede results. For example, in many cases, it takes decades to establish data-bases to properly examine trends and cumulative effects.

TECHNOLOGY PUSH

The past notion that environmental research and development was deemed "unprofitable" and, therefore, not worthy of pursuing, has resulted in unsatisfactory participation by the private sector in most Western countries.² The need for government research and development is based on the premise that the private sector cannot, or is unwilling, to pursue the scientifically optimal level of research necessary to maintain a clean environment.³ Government intervenes in research areas which the private sector deems to be unprofitable and fails to pursue. Thus, environmental R&D has been characterized by "technology push" rather than by "market pull".

Accordingly, environmental research cannot be judged by traditional methods of proving the economic and commercial returns of R&D expenditures.

Moreover, the past notion of the non-profitability of environmental research is being challenged. Clean technologies often result in more efficient use of resources and therefore can increase profitability and competitiveness. Indeed, the marketing of clean technologies has the potential of becoming a key growth sector in the next decade. The importance of technology transfer, therefore, within the evaluation of Air Quality Services and Atmospheric Research, should be fully examined especially in the context of the principles of sustainable development.

2. Environmental Policy and Technical Change:
OECD: Paris, p. 34.

3. Ibid., p. 10.

4.5 OTHER CONSIDERATIONS

MANAGEMENT AUDIT OF ATMOSPHERIC RESEARCH DIRECTORATE

The 1988 audit of Atmospheric Research Directorate focused on the strategic management of Human Resources, with particular emphasis on:

- scientist/infrastructure balance
- research/development balance
- technology transfer
- recognition for performance

Annex D includes the business profile of the Directorate. Since these management issues have already been examined, a management-oriented evaluation would seem unnecessary. Rather, the proper management of scientific personnel and the resulting conducive research environment should be seen as an essential element to the success of the program and examined in that light.

INVOLVING THE RESEARCH COMMUNITY

It is essential that the research community be involved in all steps of the evaluation planning and process in order to enhance the quality and relevance of the evaluation.

OPERATIONAL PLANNING FRAMEWORK (MAY 1989 - approval pending)

Annex E outlines the Operational Planning Framework.

4.6 POTENTIAL DATA COLLECTION METHODOLOGIES

LITERATURE REVIEW AND FILE REVIEWS

- ° A review of internal and external reports, program documentation, journals and other relevant literature.

IN-DEPTH INTERVIEWS WITH PROGRAM MANAGEMENT

- ° In-person interviews with senior management.

CLIENT/CUSTOMER SURVEYS

- ° Mail, telephone, or in-person interviews with a sample of Air Quality Services and Atmospheric Research's clientele and/or stakeholders.

EXPERT OPINION AND REVIEW

- ° Mail, telephone or in-person interviews with experts in the area of research that Air Quality Services and Atmospheric Research is focused.

FOCUS GROUPS

- ° Carefully planned discussions designed to obtain perceptions on a defined area of interest.

CASE STUDIES

- ° In-depth studies of individual program cases.

ECONOMIC ANALYSIS

- ° Cost-effectiveness analysis
- ° Rate of return analysis.

PEER REVIEW OF QUALITY OF SCIENCE

- ° This method allows for an objective examination of scientific research by experts in the field. Again, modifications in evaluation design should be made for bias.

CITATION ANALYSIS

- ° A quantitative measure of the references made to Atmospheric Research provides a perspective of the quality of research conducted within the department.

PUBLICATION COUNTS

- A quantitative measure of scientific publications, including papers published in reference journals.

AWARD AND HONOURS COUNTS

- A quantitative measure of scientific awards and honours.

PATENT COUNTS/ANALYSIS

- A quantitative measure of patent counts.

Sub-Objectives of the ARD Strategic Plan

(a) Scientific Credibility

- (i) To increase the effectiveness of the research management process within ARD.
- (ii) To improve the environment for performing research within ARD.
- (iii) To provide for regular, external, peer advice and review of ARD programs.

(b) Client Relations

- (i) To improve the transfer of ARD knowledge and technology to clients.
- (ii) To develop a more structured approach to determining client needs.

(c) Partnerships

- (i) To increase the use of personnel exchanges, consortia and joint undertakings with OGD's, provinces, universities and the private sector to meet ARD goals when it is in the national interest to do so.
- (ii) To continue to participate as a partner in international studies when it is in the national interest.

(d) Market Niche

- (i) To build and maintain a high quality research capability in the areas chosen for primary ARD focus.
- (ii) To ensure that, for research requirements falling under ARD's resourcing or advisory purview, those best qualified and available will get the job.

(e) Policy Advice

- (i) To improve ARD communications with the public.
- (ii) To improve ARD communications with appropriate policy sectors within the federal government.

MANAGEMENT OF THE RESEARCH SCIENTISTS POPULATION

The classification for Research Scientists (RES) is incumbent-oriented, i.e., their classification is not related to their job description, it is related to their performance as measured by their scientific productivity, their creativity, their influence and the recognition of their work by their peers. As a result, line managers are very much involved in the classification of their research scientists.

Three Committees exist to assist managers and to formalize decisions:

- The Inter-departmental Advisory Committee for the Scientific Research Group
- The DOE Committee for the Scientific Research Group
- The AES Committee for the Scientific Research Group

The terms of reference for each committee are similar. However, their authority increases with each level.

The Director General for Atmospheric Research Directorate is responsible for the operation of the AES Committee. More specifically, his responsibilities are:

1. Management of the Scientific Research Group

- Overall responsibility at the Service level for the administration of the Scientific Research Group on behalf of the ADM;
- Review and suggest improvements (to the DOE Committee) in policies; and
- Monitor the performance assessments.

2. Appointments to the Research Scientist Sub-Group

- Approve or reject all appointments to levels RES-1 or RES-2 (either within or outside the public service; and
- Recommend or reject all cases for appointment to levels RES-3 or RES-4 (either within or outside the public service).

3. Annual Promotion Exercise

- Approve or reject all promotions to level RES-2; and
- Recommend or reject all other cases.

METEOROLOGICAL SERVICES
RESEARCH BRANCH

LA RECHERCHE EN PREVISION NUMERIQUE

Activities:

The primary role of the Division de la recherche en prevision numerique (RPN) is to carry out research and development in support of the AES Numerical Weather Prediction programme. The Division, which is collocated with CMC in Montreal, has developed an international reputation for scientific excellence and many of the techniques they have developed have been implemented at other centres around the world.

The activities include:

Enhancement of Operational Models

The Division provides scientific support to CMC operations by identifying and resolving problems in the physics and mathematics of the operational models.

Numerical Analysis Techniques

The Division has made significant contributions to the science in this area and continues to be a world leader. The techniques have allowed AES to run finer-scale numerical weather prediction models than would otherwise have been possible with the limited computer resources at CMC.

Data Assimilation

Accurate initial analyses have become an increasingly important aspect of numerical weather prediction. Data assimilation is being given much more attention both in Canada and internationally. This interest is not limited to weather forecasting applications. The data assimilation activities are expected to also become important for climate change and trace gas monitoring. At present RPN is placing emphasis on the assimilation of satellite data in an effective manner.

Physical Parameterization

Simulation of the effects of atmospheric phenomena smaller than the resolution of the models becomes increasingly difficult as the resolution of the models increases. It is an important area of numerical weather prediction research because of the importance of small-scale phenomena on the development of weather systems.

Model Development

The models operating now at CMC were all developed by RPN. The move towards the WSO concept and the greater interest in meso-scale phenomena will require further refinements in the resolution of the models. To this end the Division is engaged in the development of a new model in collaboration with the University of Quebec at Montreal.

Compare

The Compare project is an international project to compare the performance of forecast models. The project is headed by Dr. Andrew Staniforth of RPN and 70 modelers and modelling groups from around the world have been invited to participate. The first tests will use the CASP data set. A first milestone will culminate in an international scientific meeting in Montreal in 1991.

Key Issues at Present

Finer resolution models and the assimilation of satellite data require a substantial increase in computer power at CMC.

It is difficult to find and attract a world class specialist in data assimilation to work in Canada.

Resources 1989/90

	PY's	O&M	CAP
A Base	22.0	125K	30K
Other			
Total	22.0	125K	30K

CLOUD PHYSICS

Activities:

Cloud Chemistry

Research on the role of clouds on the chemistry of the atmosphere and precipitation.

CHEF (Chemistry of High Elevation Fog) Project operates two observation sites in Quebec to study the role of fog on forest decline.

Airborne programme, with an international reputation for excellence, carried out using aircraft from the National Aeronautical Establishment and Innotech Aviation to make cloud chemistry, cloud physics and aerosol measurements.

Cloud Physics

Research on the role of clouds and the precipitation process on the development of severe convective storms and extra-tropical cyclones.

CASP (Canadian Atlantic Storms Project) to investigate the physics of storms off the east coast. Carried out in conjunction with the US GALE project.

ERICA (Evolution of Rapidly Intensifying Cyclones over the Atlantic). Participation in this US project.

CASP II, an investigation of the meso-scale aspects of Atlantic storms off Newfoundland.

Camanchaca Project to extract drinking water from fog in Chile carried out in collaboration with IDRC and WMO. Other sites in the middle east are being investigated. This project is an offshoot of our work to capture fog droplets and analyse their chemical composition.

STORM, a series of large field experiments (\$250M over 10 years) to be undertaken by the US during the 1990's to investigate the development of severe weather systems. A Canadian equivalent to this project is being planned.

Radar Meteorology

Research on the use of weather radar for weather forecast operations and atmospheric research.

Development and operation of the King City Radar.

Development and provision of operational radar products to the Ontario Weather Centre and others.

Investigation of the applications for Doppler radar data in weather forecasting and research.

Development of a vertical wind profiler capability at Egbert to support research and operations.

Key Issues at Present

Closing of at least one CHEF site.

AES Doppler Radar Plan promised for the fall by the Minister.

Difficulty of attracting a specialist in Doppler radar meteorology to the Toronto area.

Resources 1989/90

	PY's	O&M	CAP	Source
A Base	17.3	521K	478K	
Other	1.0	333K	100K 250K	PERD AES-CHEF AES-Doppler
Total	18.3	854K	828K	

FORECAST RESEARCH

Activities:

Artificial Intelligence

Research and development on the application of AI and expert system technologies to weather forecasting services.

Severe weather expert systems (KASSPr and SWIFT) undergoing field trials at the Alberta Weather Centre.

Technical project management of a Transport Canada project with le Centre de recherche informatique de Montreal (CRIM).

Shootout 89, international comparison of expert systems for severe weather forecasting.

Forecast Production Assistant

The development of a computerized assistant for operational meteorologists that has the capability of producing most text products from a time series of weather prediction charts.

A prototype operational FPA for marine forecasts for the Atlantic and Ontario will be completed in March.

Statistical Weather Element Prediction

Seeking new methods from the field of statistical analysis, testing their applicability to weather forecasting and developing products for operational use. These products include surface wind forecasts, snow-squall forecasts, forecast guidance for the Olympics at Calgary.

Environmental Prediction

Research and development of operational procedures for environmental parameters. These include storm surge forecast techniques, spectral wave forecasts, oil spill models, ice and ice berg motion forecasts.

Key Issues at Present

The scope of the Division's activities is too broad for the present level of resources and the content of the programme is heavily governed by the availability of outside resources.

Resources 1989/90

	PY's	O&M	CAP	Source
A Base	16.0	*115K	59K	
Other	1.5	233K 100K		PERD WSD (FPA) (Frozen at present) AES (AI-CRIM Project)
Total	17.5	61K 509K	59K	

AEROSPACE METEOROLOGY

Activities:

Wind Engineering

Research on the effects of wind on structures and the use of wind tunnels to simulate and study the atmospheric boundary layer (lowest 1000 feet or so). Programme terminated as of this fiscal year and staff reassigned.

Satellite Operations

Operation of the Toronto AES operational read-out station 1965-1989. Transferred to CSD.

Development of Satellite Read-Out Stations

Design and development of facilities to read-out data directly from US weather satellites and process the data for operations and research. The programme is being phased down to research facilities only, operational stations are now available commercially.

Development of techniques utilizing satellite data for weather and ice forecasting operations. At present the programme includes RAINSAT, satellite soundings for NWP, and sea surface temperatures.

Research on the physics of remote sensing of the structure and composition of the atmosphere by satellite.

Key Issue at Present

Redirection of programme from one with emphasis on development to one with emphasis on research.

Resources 1989/90

	PY's	O&M	CAP	Source
A Base	20.1	563K	6K	
Other			240K	AES-Satellite R&D
Total	20.1	563K	246K	

AIR QUALITY AND
INTER-ENVIRONMENTAL
RESEARCH BRANCH

STRATOSPHERIC OZONE

Activities:

After many years of research and systematic ozone monitoring, there is now clear evidence of a thinning of the global ozone layer and that man-made chlorofluorocarbons (CFCs) are implicated as the essential cause. It is anticipated that this ozone depletion will increase the intensity of damaging solar ultraviolet radiation at the earth's surface and cause damage to a variety of biota. The greater intensity can lead to higher incidence of skin cancer, reduction of crop yields and may be harmful to animals and limit the food-generation process in the oceans.

The activities include:

Monitoring

The Atmospheric Environment Service (AES) operates the Canadian network of ozone measurements which currently consists of stations at Toronto, Saskatoon, Goose Bay, Edmonton, Churchill, Resolute and Alert.

Modelling

In addition to measuring ozone, the AES at Toronto has developed a number of computer simulation models for predicting the effects of various perturbations on the ozone layer.

Instrumentation

In the past, the total amount of ozone above a station and the variation of ozone concentration with altitude were usually measured with a Dobson instrument. Automatic measurements of ozone have been carried out more reliably in the last few years with a new system, called the Brewer ozone spectrophotometer. This instrument was designed and developed at AES headquarters.

It offers both theoretical and operational advantages, and therefore has replaced the Dobson in the Canadian network. It is increasingly augmenting and replacing the Dobson also in the global network. There are now over twenty other countries, distributed across the globe, that operate at least one Brewer. The Dobson and Brewer total ozone measurements are frequently combined with data from ozone sondes, attached to small balloons rising through the atmosphere. This method defines the variations of ozone concentration with altitude, that is, the ozone profile. Monitoring ultraviolet irradiance has been initiated in the Canadian Brewer network in order to detect increases in biologically damaging radiation due to ozone depletion. The new Brewer instrument is proving to be a valuable tool for scientists as it makes measurements easier and more precise.

Development of small and light instruments capable of being launched on small balloons provides impetus for research of stratospheric ozone in hostile environments such as the Arctic.

Project STRATOPROBE

Since 1974, with the start of Project STRATOPROBE, scientists at AES have also studied the altitude profiles of stratospheric gases that directly and indirectly affect the ozone layer. This research is carried out by means of remote-sensing apparatus suspended from high-altitude balloons. Data obtained on flights at different latitudes and in different seasons are valuable for detecting variability and trends in gases such as CFCs. Balloon flights made to coincide with similar flights conducted by other scientific groups, or with satellite overpasses, have led to a better understanding of the results obtained from different measurement techniques and have facilitated validation of remote sensors on board satellites. Most recently, in view of the alarming ozone reduction in the Antarctic spring, AES has launched its stratospheric balloon flights from Alert to study possible ozone depletion in Canada's high arctic.

Recently high-altitude measurements have also been made with an AES instrument from a space shuttle by Canadian astronaut Marc Garneau. Currently three instruments are being developed for space shuttle flights starting in 1991.

World Ozone Data Centre

The AES has been given the responsibility by the World Meteorological Organization (WMO) to manage the World Ozone Data Centre (WODC). This task consists of carefully compiling, archiving, and publishing a daily summary of measurements from the global network.

Key Issues at Present

- Existence of Arctic Ozone Hole
- Role of Brewer in global O₃ Monitoring
- Montreal Protocol

Resources 1989/90

PY
17.0

O&M
1,200

CAP
450

GREENHOUSE GASES: MEASUREMENT AND RESEARCH

Activities:

The concentrations of some trace gases in the troposphere, notably carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), chlorofluorocarbons (CFC's) and ozone (O_3), are increasing. These gases are essentially transparent to incoming short-wave solar radiation but they absorb and emit long-wave radiation, thus causing climate warming. CO_2 is the most important greenhouse gas, but the other gases combined have an equivalent warming effect.

The activities include:

Flask Sampling Program

CO_2 flask samples have been collected at Alert and Sable Island since 1975, and at Cape St. James since 1981. A number of cooperative flask sampling programs have been initiated at Alert with other agencies. They extend the measurements to isotopes of carbon and oxygen and also to other greenhouse gases including CH_4 and CFCs.

Continuous Monitoring Program

Whereas flask sampling is useful to identify trends and annual cycles, continuous monitoring is necessary to obtain more accurate measures of annual average concentrations, of the magnitude of the amplitude of the annual cycles, as well as to identify sources and sinks and to eliminate data influenced by local sources.

Alert was selected because of its unique location as the world's most remote northerly station at 82.5°N 62.3°W . It fills an important gap in the global baseline network of stations designed to study the spatial distribution of radiatively active pollutant gases and particles. It also offers a unique opportunity to characterize air pollution in the north polar region.

Our first laboratory for the continuous monitoring of global air pollution was officially opened in August, 1986. This new research facility in the high Arctic signifies Environment Canada's commitment not only to our own environment but also to that of the international community at large.

Three of the greenhouse gases are now being measured: CO_2 , CH_4 , and O_3 using infrared, gas chromatographic and spectrophotometric techniques, respectively. Ancillary measurements combine to assist in identifying the origin of air masses and, hence, the source regions.

Hudson Bay Lowlands Methane (CH_4)

Wetlands are known to be source regions for atmospheric methane. The Hudson Bay Lowlands represent one of the largest wetland areas in the world and very little is known about its role in determining the global methane budget. A multi-agency research program has been designed to measure fluxes of CH_4 , CO_2 and other gases over the Hudson Bay Lowlands using aircraft and ground based techniques in collaboration with a NASA ABLE-3B experiment planned for the summer of 1990. A northern wetlands "chemical

observatory* to measure CH_4 and collect other chemical climatological data over all seasons and over a number of years is now being established. AES will act as the lead agency and CIRAC will provide coordination. Other participants include NRC, DFO, Agriculture Canada, NWRI, CCRS and a number of universities including McGill, Guelph, York and McMaster. AES and York University have obtained NSERC support through a joint Industry-University Research Proposal.

Global Climate - Carbon Cycle Model

In order to predict the future evolution of the climate system forced by increases in the atmospheric CO_2 content, we need to acquire, among other things, knowledge and ability to predict future levels of CO_2 in the atmosphere. Since many of the processes which govern CO_2 fluxes among various carbon reservoirs are temperature dependent, increasing temperature in the atmosphere would alter the amount of carbon exchanged among the reservoirs. Thus, there is an important feedback coupling between the evolution of the climate and the global carbon cycle.

Key Issues at Present

What are the composition of the greenhouse gases? What are their trends? How are the contributions of the gases partitioned between natural and man-made?

Resources 1989/90

PY
6.5

O&M
303

CAP
670

ACID RAIN AND REGIONAL SMOG (LRTAP)

Activities:

Acid rain and its effects has been a major environmental issue for a decade. To reduce the problem, the Canadian sulphur control program will lower sulphur dioxide emissions by 50% by 1994. Amendments to the US Clean Air Act will significantly reduce the transboundary flow of sulphur providing that the emission reductions are targeted appropriately. Both emission reduction plans will serve to reduce acid deposition to below environmental targets. The effectiveness of the control measures needs to be monitored.

Consideration must be given to the post-1994 Canadian position on sulphur dioxide emission control at both the domestic and international level. The present AES capability to provide advice and information must be continued in order to help develop the post-1994 strategy.

Another regional air quality issue is the high concentrations of ozone (smog) in eastern North America. A Federal/Provincial task force is preparing an action plan for CCEM to address this issue nationally. AES is contributing to the task force by providing technical information in order to define options and their consequence to reduce the problem.

The activities include:

Modelling

Modelling is the development of source/receptor relationships between emission sources and environmental receptors through either developing air quality simulation models or the empirical analysis of field measurements.

Monitoring

Monitoring is the routine description of air quality and precipitation chemistry across Canada to describe the geographical scope and intensity of the problems and to determine if the situation is improving as a consequence of announced and proposed emission reductions in Canada and the United States. Detail of the monitoring network, CAPMoN, are described following.

Process Studies

Process studies investigate the processes whereby the pollutants of interest are transported through the atmosphere, chemically transformed and ultimately deposited. Research into processes provide the basic knowledge required for formulating the air quality models mentioned above.

Key Issues at Present

The LRTAP IV funding ends this fiscal year and AES has provided input to the LRTAP V submission.

Resources 1989/90

	PY	O&M	CAP	G&C
A-Base	33.4	332.2	400.7	55
LRTAP IV	1	1173.0	410	-

CANADIAN AIR AND PRECIPITATION MONITORING NETWORK (CAPMoN)

Activities:

The CAPMoN network of 24 stations was established in 1983 to conduct regional monitoring of air and precipitation chemistry. There are more stations in eastern Canada where the acid rain problem is most evident.

In addition to the existing monitoring programs, the CAPMoN network has the potential to serve as a platform or backbone from which other national air quality monitoring programs are launched. The sites meet rigid selection criteria which ensure that there are no local sources of pollution and that the measurements are representative of large geographic areas.

Several of the stations are strategically located in watersheds where other agencies are also conducting research measurements. This cooperation with other agencies to colocate studies and to conduct integrated monitoring is an effective way to reduce duplication of effort and to ensure maximum use of data.

The activities include:

Precipitation Chemistry Monitoring

Precipitation samples are collected on a daily basis at each of the 24 CAPMoN sites. These samples are shipped to a central laboratory at CCIW's facilities in Burlington for chemical analysis. Routine analysis of pH and of each of the major ions (sulphate, nitrate, chloride, phosphate, ammonium, calcium, magnesium and potassium) is performed.

The goal of precipitation chemistry monitoring is to provide a continuous high quality data set which can be applied to further our understanding of the many issues related to acid rain (wet deposition).

Air Chemistry Monitoring

Air chemistry is presently monitored at 11 CAPMoN sites. These sites are colocated with the precipitation monitoring program. A newly developed (Canadian) sampling system was installed in 1988.

Air chemistry is monitored by pulling a known volume of air through a filter pack which is loaded with various filters. Each filter within the filter pack is designed to trap specific atmospheric constituents. CAPMoN uses a 3 stage filter pack, of Canadian design, which allows for laboratory analysis of major ions (sulphate, nitrate, chloride, phosphate, ammonium and potassium).

The goal of air chemistry monitoring is to provide a continuous high quality data set which can be applied to further our understanding of dry deposition.

Ground Level Ozone Monitoring

The issue of increasing ground level ozone concentrations has received increased public attention recently. The CAPMoN network began continuous monitoring of ground level ozone in the spring of 1988. Ozone is monitored at each of the 11 air sampling sites.

The purpose of the ground level ozone monitoring program is to generate a continuous high quality data set which can be applied to further our understanding of how urban oxidants are transported to rural areas.

EMEFS Project

The Eulerian Model Evaluation Field Study (EMEFS) is an international research project which has as its goal to evaluate the capabilities of computer models to add important atmospheric chemistry processes to the existing meteorological conditions. The project began in mid 1988 and will conclude in mid 1990.

CAPMoN's role has been to collect and provide data that will be used to assess how well the models simulate air concentrations and wet and dry deposition.

NOx Monitoring

The NOx protocol has placed increased pressure on AES to develop a methodology for monitoring NO₂ in a network setting. A project is being launched in 1989/90 to identify potential systems and to begin feasibility testing.

pH in Precipitation Program

A subset of 5 CAPMoN sites are equipped with an additional precipitation collector. The pH of the precipitation is measured by the field operator and reported to Quebec Region Scientific Services Division. SSD staff then calculate back-trajectories to determine the most likely path the air followed. The results are presented in the Acid Rain Bulletin which receives some media coverage in newspapers.

This program is primarily for public consumption. This is a way of gaining regular coverage for the acid rain issue, but one which is manpower intensive.

Key Issues at Present

CAPMoN resources have been provided entirely from LRTAP project funding. The future of LRTAP funding depends on approval of the LRTAP V Memorandum to Cabinet.

Resources 1989/90

PY

O&M

CAP

INCLUDED UNDER LRTAP

ENVIRONMENTAL EMERGENCY RESPONSE

Activities:

Environmental emergencies occurring during the past decade have effected the lives of many Canadians. With the introduction of new emergency legislation, federal government departments have reviewed their policy and emergency response capabilities. In Environment Canada, AES has taken a leadership role in this development through its emergency preparedness coordination responsibilities and participation on interdepartmental committees lead by Emergency Preparedness Canada (EPC) and on international working groups.

The activities include:

Emergency Preparedness Coordination

With a focus on pollution emergencies, the Environmental Emergency Response (EER) Program is coordinated for AES by the Atmospheric Research Directorate (EER Program Advisor). Service-wide procedures, research and development, training and exercises, and communications are coordinated through secretariat and work group roles on emergency preparedness committees of AES and Environment Canada. The recently approved "AES Policy on Peacetime Emergency Response" (AMC, April 20, 1989) provides the basic framework for program improvement and coordination.

Realtime Emergency Responses

AES provides assistance during emergencies by giving advice and technical support on weather, air quality, ice and sea-state. Through regional and headquarters offices across the country, AES maintains a 24 hour 7 day a week capability to respond to local, regional, national and international events.

Emergency response models are operated on varying scales for air dispersion and oil spills on water. AQPAC, CANERM and SLICK (operated by regional and CMC offices) provide timely and accurate (within the limits of the data available) advice to lead responders. The main task of AES in running these models is to provide emergency response agencies with advice on the physical boundaries of the "hazard zone" in space and time based on expert atmospheric information.

An important activity of AES is providing weather data - observed and forecast parameters - representative of the site and area of release. This information is valuable input for site forecasts, dispersion models, mesoscale wind fields, indices (stability, severe weather, etc.) and post evaluation studies. AES also collects air and precipitation samples routinely at 26 sites across Canada for radionuclide analysis by Health & Welfare. During emergencies, the sampling frequency may be increased.

Emergency Communications

An essential emergency support activity is assisting response agencies and the public through communications services: to notify, advise, activate plans and services, transfer data and products, and distribute public messages.

In cooperation with other agencies, AES is evaluating and testing communication procedures and telecommunications systems for emergency applications. These include an environmental hotline, weatheradio, ATADs, National Communication Systems (METSIS, NCCS) and international systems (GTS, FAX).

Key Issues at Present

While AES is able to respond well to meteorological emergencies, there is a need to improve our capability during events involving hazardous releases to the atmosphere or spills on water.

Resources 1989/90

PY
10.0*

O&M
26.0

CAP
545.0

*Note 6 PY's are in the Regions

**BUSINESS PROFILE: ENVIRONMENT CANADA - ATMOSPHERIC
RESEARCH**

A. COMPETITIVE POSITION

B. INDUSTRY ATTRACTIVENESS

C. CAPITAL & PRODUCTION STRUCTURE



ATMOSPHERIC RESEARCH

THE INDUSTRY:

- VERY CONCENTRATED INDUSTRY (60%)
- FLAT INDUSTRY GROWTH RATE (0%)
- VERY HIGH INVESTMENT INTENSITY (127%)
- CUSTOMERS' INDUSTRY SEGMENT IS VERY CONCENTRATED (85%)
- SUPPLIERS' INDUSTRY SEGMENT IS VERY CONCENTRATED (85%)
- VERY LONG NEW PRODUCT DEVELOPMENT TIME (48 MO.)
- PURCHASE ORDER AMOUNT: \$100,000 - \$1,000,000
- SALES DIRECT TO OEM'S (>90%)

THIS BUSINESS:

- HAS A LOW MARKET SHARE (10%)
- SELLS A HIGH QUALITY 'MERCEDES' PRODUCT (140%)
- PRICES ITS PRODUCT SLIGHTLY LOWER THAN COMPETITION (95%)
- COSTS LESS TO MAKE THAN COMPETITION (95%)
- SELLS TO A VERY CONCENTRATED CUSTOMER BASE (2%)
- BUYS FROM A FRAGMENTED SUPPLIER BASE (45%)
- WORKING CAPITAL LEVELS ARE LOW (2%)
- HIGH UNIONIZATION (80%)
- NARROWER PRODUCT LINE (80%)
- NO SALES FORCE (0%)
- HIGH NEW PRODUCT SALES (23%)
- PRODUCT MANUFACTURED FOR CUSTOMER ORDER (50%)
- HIGHER COMPENSATION (120%)
- HIGH CAPACITY UTILIZATION (90%)
- LOW MARKETING (4%)

**PROFILE DETAILS: ENVIRONMENT CANADA - ATMOSPHERIC
RESEARCH**

- A. MARKET SIZE AND ATMOSPHERIC RESEARCH
(ENVIRONMENT CANADA) SHARE**
- B. COST STRUCTURE**
- C. INVESTMENT STRUCTURE**
- D. PRODUCT SEGMENT/CUSTOMER PROFILE**

ENVIRONMENT CANADA - ATMOSPHERIC RESEARCH PROFILE

A. Competitive Position

Sales Revenue	\$13.00	(Million)
Market Share	10%	
Market Concentration	80%	
Business Sales Growth	0%	
Level of New Product Sales	23%	
Image/Quality of Product	140%	
Relative Price	95%	
Relative Cost	95%	

B. Industry Attractiveness

Market Size	\$130.00	(Million)
Market Growth	0%	
Investment Intensity	127%	
Purchase Amount-Immediate Customers	\$100000 -	\$1000000
Concentration of Suppliers (Own Industry)	85%	
Concentration of Buyers (Own Industry)	85%	
Distribution Expense/Sales	0%	
Level of R&D	15%	
Immediate Customer Buying Power	2%	
(50% of Sales Represent ? % of Customers)		
Negotiating Power With Suppliers	45%	
(50% of Purchases Represent ? % of Suppliers)		

C. Capital & Production Structure

'Raw Material' Purchases	33%	
Manufacturing/Service Costs	38%	
Sales Force Expense	0%	
Working Capital Levels	2%	
Unionization	80%	
Capacity Utilization	90%	
Value Added per Employee	\$50.00	(Thousand)
Number of Employees	178	
Gross Plant & Equipment	125%	
Net Plant & Equipment	125%	
Depreciation	18%	

ATMOSPHERIC RESEARCH
PRODUCT SEGMENT/
CUSTOMER PROFILE

(1987)

- THE CONSUMER PERCEPTION IS THE 'MERCEDES'.
- THE % SALES BY OWN EMPLOYEES IS >90%. THE % SOLD TO OEM'S IS >90%.
- CUSTOMER NEGOTIATING POWER (2% OF THE CUSTOMERS MAKE UP 50% OF THE SALES).
- VERY CONCENTRATED TARGET CUSTOMER SEGMENT: THE 4 FIRM CONCENTRATION RATIO IS 85%.
- THE PRODUCT IS A RELATIVELY IMPORTANT PURCHASE TO THE IMMEDIATE CUSTOMER.

II. PROFITABILITY EXPECTATIONS:

Where Should We Be?

**Threats and Opportunities Impacting
ENVIRONMENT CANADA - ATMOSPHERIC RESEARCH**

DETERMINING WHAT'S 'NORMAL'

CVH ROI REPORT

Factor	Company	Profit Impact
1 MARKET POSITION	0.15	0.230
2 QUALITY	1.40	-0.617
3 REL PRICE	0.95	0.531
4 REL COST	0.95	-0.631
5 COMPETITOR CONC	0.60	-0.521
6 NEG PWR CUSTMER	0.02	0.234

CVH ROI REPORT

Factor	Company	Profit Impact
7 NEG PWR SUPPLR	0.45	0.216
8 UNIONIZATION	0.80	0.528
9 COMPENSATION	1.20	0.324
10 CAPACITY UTIL	0.90	-0.347
11 LABOR	0.38	0.400
12 R&D	0.15	-0.100

CVH ROI REPORT

Factor	Company	Profit Impact
13 TTL WORKING CAP	0.02	-0.143
14 TTL FIXED ASSET	1.25	-0.197
15 VERT INTEG	0.67	-0.240

Actual ROI 07%

Expected ROI 05%

* r2 = 76%

III. HOW DO WE GET THERE?

SPECIFIC DIRECTIONS FOR
OPTIMIZING PERFORMANCE

ENVIRONMENT CANADA - ATMOSPHERIC RESEARCH

A. CUSTOMER PROFILE POLICY

<u>Factor</u>	<u>ENVIRONMENT CANADA RESEARCH</u>	<u>Businesses That Maintained</u>	
		<u>Higher Profitability</u>	<u>Lower Profitability</u>
(1) NEGOTIATING PWR WITH CUST	0.02	0.16	0.29
(1) CUSTOMER CONCENTRATION	0.85	0.29	0.27
(2) MADE TO ORDER	0.50	0.86	0.47

Observations (Directional)

- The concentration of the customer segment seems to be higher than the winners and the company's negotiating power with the immediate customers is not as good as the winners.

- (1) NEED MORE CUSTOMERS
- (2) SHOULD MAKE MORE TO CUSTOMER SPECIFICATIONS

B. PRODUCT POLICY

<u>Factor</u>	<u>ENVIRONMENT CANADA RESEARCH</u>	<u>Businesses That Maintained</u>	
		<u>Higher Profitability</u>	<u>Lower Profitability</u>
(1) NEW PRODUCT SALES	0.23	0.09	0.21
(2) NEW PROD DEVELOPMENT TIME	48.00	11.17	18.75
(3) RELATIVE PRODUCT BREADTH	0.80	1.03	1.22
(4) RELATIVE PRICE	0.95	1.06	1.00
RELATIVE COST	0.95	0.98	1.03

Observations (Directional)

- Relative price and relative cost appear to be lower than the winners.
- New product development time is much longer than the winners, and new product sales revenue appears to be higher than the winners.
- The breadth of the product line appears to be narrower than the winners.

- (1) MAY BE TOO MUCH NEW PRODUCT EMPHASIS RATHER THAN EXPLOITING WHAT WE HAVE.
- (2) TAKES TOO LONG TO GET NEW PRODUCTS.
- (3) THE BREADTH OF THE PRODUCT LINE APPEARS TO BE NARROWER THAN THE WINNERS AND LOSERS. THIS IS AN ADVANTAGE.
- (4) COULD GET MORE IN TRADE THAN WE DO -- BECOME MORE PROFITABLE.

C. MARKETING POLICY

<u>Factor</u>	ENVIRONMENT CANADA <u>RESEARCH</u>	<u>Businesses That Maintained</u>	
		<u>Higher</u> <u>Profitability</u>	<u>Lower</u> <u>Profitability</u>
ADVERTISING	0.02	0.02	0.02
SALES PROMOTION	0.02	0.04	0.02
SALES FORCE	0.00	0.16	0.08
DISTRIBUTION	0.00	0.02	0.01
TOTAL MARKETING	0.04	0.24	0.12

Observations (Directional)

- Marketing expenses appear to be much lower than the winners.

- INTERNATIONAL CONFERENCES ETC. ARE SALES EFFORTS.
- WE PROBABLY NEED MORE EFFORT HERE -- THINK OF IT AS BARTER.

D. ASSET MANAGEMENT

<u>Factor</u>	<u>ENVIRONMENT CANADA RESEARCH</u>	<u>Businesses That Maintained</u>	
		<u>Higher Profitability</u>	<u>Lower Profitability</u>
NEGOTIATING PWR WITH SUPP	0.45	0.16	0.17
(1) SUPPLIER CONCENTRATION	0.85	0.55	0.51
(2) CAPACITY UTILIZATION	0.90	0.73	0.82
PURCHASED MATERIALS	0.33	0.22	0.43
LABOR	0.38	0.43	0.21
SHORT TERM DEBT	0.02	0.10	0.10
VERTICAL INTEGRATION	0.67	0.78	0.57
VALUE ADDED PER EMPLOYEE	49.63	84.94	56.61

Observations (Directional)

- Capacity utilization appears to be higher than the winners.
- Vertical integration appears to be lower than the winners; and purchased materials appears to be higher than the winners.
- The company's negotiating power with suppliers is better than the winners; and the suppliers industry is more concentrated than the winners.

- (1) NEED TO DEVELOP MORE SUPPLIERS.
- (2) RUNNING TOO TIGHT -- NOT ENOUGH STOCK TO RESPOND.
- (3) WE SHOULD BE MORE VERTICALLY INTEGRATED.

E. PRODUCTIVITY

<u>Factor</u>	ENVIRONMENT CANADA <u>RESEARCH</u>	<u>Businesses That Maintained</u>	
		<u>Higher</u> <u>Profitability</u>	<u>Lower</u> <u>Profitability</u>
UNIONIZATION	0.80	0.31	0.15
COMPENSATION	1.20	1.07	1.12
TOTAL WORKING CAPITAL	0.02	0.31	0.23
RECEIVABLES	0.02	0.15	0.15
SEMI-FINISHED GOODS	0.02	0.05	0.04
FINISHED GOODS	0.02	0.06	0.10

Observations (Directional)

- Receivables are lower than the winners.
- Total working capital is lower than the winners.
- Unionization and compensation appear to be higher than the winners.

**PROPOSED
RESTRUCTURED POSITION
ENVIRONMENT CANADA - ATMOSPHERIC RESEARCH
FINANCIAL EXPECTATIONS**

Certain operating characteristics of ENVIRONMENT CANADA - ATMOSPHERIC RESEARCH were replaced with those of comparable companies with higher profitability.

New ROI 27%

\$ 52.82 Million

ENVIRONMENT CANADA - ATMOSPHERIC RESEARCH

REVENUE	13.00 MILLION
INVESTMENT	16.51 MILLION
CURRENT ROI	7.00%
EXPECTED ROI	5.00%
CURRENT EARNINGS	1.16 MILLION
P/E RATIO	23.70
CURRENT VALUE	13.70 MILLION
PREDICTED ROI	27.00%
PREDICTED EARNINGS	4.46 MILLION
PREDICTED VALUE	52.82 MILLION

- A. Activity: ATMOSPHERIC ENVIRONMENT
- B. Sub-Activity: AIR QUALITY SERVICES AND ATMOSPHERIC RESEARCH
- C. Objectives: To provide information on the chemical and physical state of the atmospheric environment in order to support informed decisions relating to environmental quality.
- D. 1988-89 Resources: Pts 121 Salary 6,654 O&M 6,087 Capital 4,768 G&C 754 Total 18,263 Revenue 85 (\$000)

GOODS/SERVICES AND CLIENTS	RESULTS	CONSEQUENCES	PERFORMANCE CRITERIA
1 Data information and advice on air quality and air and precipitation chemistry, including State of the Environment reporting, for governments, private interests and the public.	1 Information and advice support intergovernmental negotiations, Canadian policy-making and public and private decisions to improve air quality.	I Threats to society from environmental emergencies and atmospheric pollution are reduced.	A Adequacy of air quality and precipitation monitoring network to support scientific investigation, policy applications and State of the Environment reporting requirements.
2 Environmental emergency planning, advice and operational support to emergency response agencies.	2 Databases and published results of scientific research confer credibility to the Canadian positions on protecting the atmosphere.	II Threats and losses to the environment are reduced.	B Examples of ability to respond to priority environmental issues and quality and timeliness of advice and information provided to policy-makers (e.g. Ozone Protocol).
3 Research on atmospheric physics and chemistry.	3 Environmental emergency modeling, advice and other input improve the suitability and timeliness of response by lead agencies.	III Improved opportunity for sustainable development over the long term.	C Examples of leadership in contributing to, and taking advantage of, scientific advances in atmospheric environmental issues.
	4 R&D findings and new technologies improve the monitoring, analysis, modeling and interpretation of trends in air quality.	IV Improved adaptation to changing atmospheric conditions.	D Record and examples of major research projects, refereed publications, significant R&D findings and their applications.
			E Reaction time and quality of response to environmental emergencies (both real and simulated).